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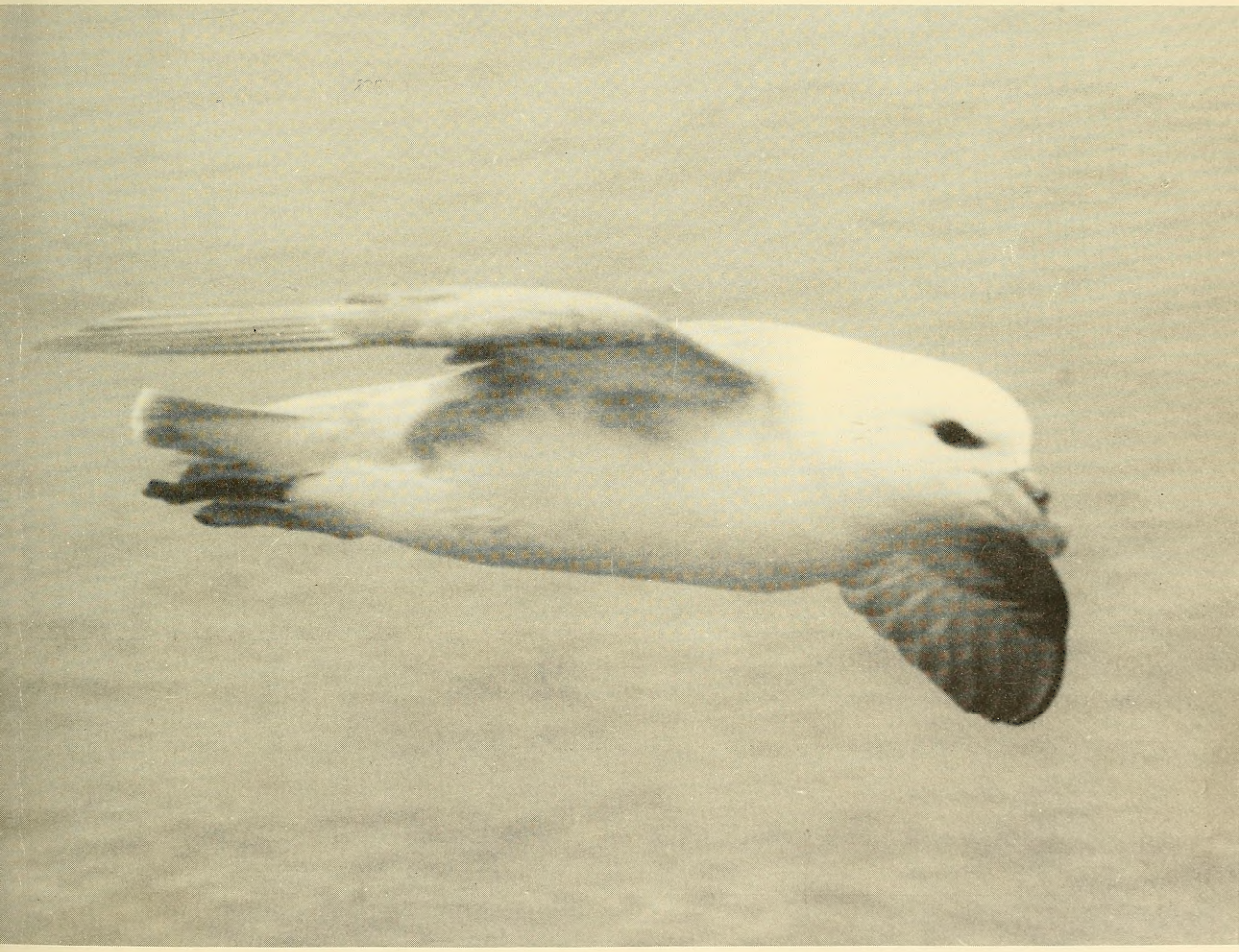

Volume 92, Number 1

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Cover: Northern Fulmar photographed by W. A. Montevecchi on 1 June 1977 as it flew off the cliffs of Baccalieu Island, Newfoundland where it nested. See Note on page 80.

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The Canadian Field-Naturalist

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Rearing Atlantic Salmon (*Salmo salar*) in Fishless Lakes of the Matamek River System, Quebec[1]

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Rimmer, D. M. and G. Power. 1978. Rearing Atlantic Salmon (*Salmo salar*) in fishless lakes of the Matamek River system, Quebec. Canadian Field-Naturalist 92(1): 1–9.

An attempt to utilize fishless lakes for producing smolts of Atlantic Salmon (*Salmo salar*) resulted in exceptional growth, but poor survival and no migration. On diets of zooplankton with a high proportion of larvae of Chaoboridae and Chironomidae, alevins grew at rates of 0.54–0.67 mm·day^{-1}, yearlings attained mean fork lengths of 168 mm, and 3+-year-old fish averaged 404 mm fork length. These growth rates are greater than any other recorded for Atlantic Salmon in fresh water. Condition factors were high, ranging from 1.17 to 1.60. The findings indicate that Atlantic Salmon can survive and grow well in these fishless lakes, but great care must be taken to ensure that survival is good. Also, if this potential management technique is to be successfully developed, a solution to the non-migration problem must be found.

Key Words: Atlantic Salmon, fisheries management, fish introduction.

Atlantic Salmon (*Salmo salar*) populations will continue to decline from the effects of debasement of their environment (Netboy 1974) and increased relative fishing pressure (Paloheimo and Elson 1974) unless ways are found to supplement or replace natural production. In both Norway (Berg 1967) and Britain (Harris 1973), fishless lakes and tarns have been used with some success to raise salmon smolts. The technique offers a possible alternative to artificial rearing, which, although highly refined (Peterson 1971), has become extremely costly. Fishless lakes in the headwaters of the Matamek River (Power et al. 1973) offered an opportunity to study this management technique in Quebec. The lakes contained dense limnetic populations of larval *Chaoborus* spp. (Pope et al. 1973) as well as smaller zooplanktonic crustaceans that could serve as natural food. Lack of predation and interspecific competition were expected to lead to high survival and rapid growth of the fish. It was anticipated that smoltification, which is closely related to size (Elson 1957), would occur early in life and it was hoped that the smolts would migrate to the sea to supplement the natural smolt run from the Matamek River. This communication presents the results of alevin (Balon 1975) planting between 1970 and 1974 in four fishless lakes.

Study Areas

The lakes used in these experiments were Gallienne, Randin, Head, and Crosskey (Figure 1). All lie on the slow-weathering igneous rock of the Canadian Shield and are surrounded by boreal forest. Selected morphometric characteristics are given in Table 1. Gallienne and Randin are deep lakes with only 13% and 2.5% of their surface area, respectively, being less than 2 m deep. Aquatic vegetation is sparse in all lakes and consists of *Nuphar, Sparganium, Potamogeton, Vallisneria, Ceratophyllum, Chara, Lemna, Myriophyllum,* and *Anacharis* in that order of abundance. The lake bottoms consist of stones, sand, silt, and detritus in various proportions around the shores and a highly organic gel-like silt in the deeper areas.

[1]Contribution Number 32 of the Matamek Research Station, Sept-Iles, Quebec

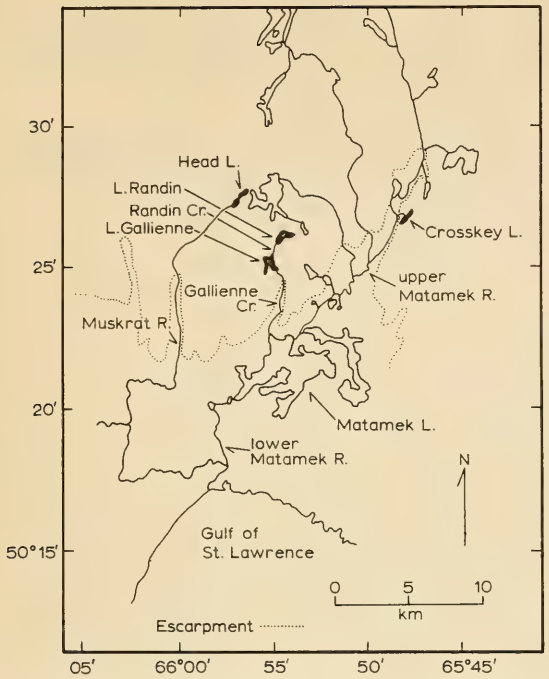


FIGURE 1. Portion of the Matamek River system, Quebec showing the four study lakes and the Laurentian Escarpment.

A small stream, Randin Creek, offering good alevin habitat in the lower reaches, connects Lakes Randin and Gallienne. Lake Gallienne discharges via Gallienne Creek to Matamek Lake, then via the Matamek River to the Gulf of St. Lawrence. Head Lake forms the headwaters of the Muskrat River which supports a natural salmon population in its lower reaches below the escarpment. Crosskey Lake is drained by a tiny riffle which flows for 400 m before descending precipitously down the escarpment to join the upper Matamek River.

Chemical analyses of midsummer water samples from Gallienne, Randin, and Crosskey Lakes are given in Table 2. It is assumed that Head Lake is similar. These lakes resemble typical Shield lakes as described by Armstrong and Schindler (1971).

TABLE 1—Selected morphometrical characteristics of the four study lakes

	Gallienne	Randin	Crosskey	Head
Area (ha)	39.6	41.6	12.0	12.6
Altitude (m)	290	312	343	260
Volume ($m^3 \times 10^6$)	3.96	14.40	—	—
Maximum depth (m)	44	70	17	11
Mean depth (m)	10.9	34.7	—	—
Shoreline ($m \times 10^3$)	5.92	3.71	2.52	1.70

TABLE 2—Chemical analyses of lake water showing midsummer conditions

	Gallienne	Randin	Crosskey
pH	6.1	—	6.3
Specific conductance[a] ($\mu mho \cdot cm^{-1}$ at 25°C)	14.5	13.6	14.4
Dissolved oxygen ($mg \cdot L^{-1}$)			
surface (1 m)	8.9 (9.8)[b]	—	8.5
hypolimnion (10 m)	9.3 (7.3)[b]	—	4.2
Alkalinity ($mg \cdot L^{-1}$ $CaCO_3$)	2.4	—	1.2
Ca ($mg \cdot L^{-1}$)[a]	0.37	1.27	0.70
Mg ($mg \cdot L^{-1}$)[a]	0.19	0.36	0.02
K ($mg \cdot L^{-1}$)[a]	0.19	0.12	0.05
Na ($mg \cdot L^{-1}$)[a]	0.83	1.42	0.36

[a]From Pope (1973).
[b]In parentheses — 7 March 1974 (under ice).

Materials and Methods

Alevins for planting were provided by the Provincial Fish Hatchery at Tadoussac, 475 km southwest of Matamek. They were progeny of wild fish taken near the mouth of the Saguenay River, presumably of St. Marguerite River stock. The alevins were planted at about 70 days post-hatch; they had been fed for 2 weeks. Transport was by truck to Sept-Iles, taking 6.5 h, then by helicopter to the planting site, taking 15–30 min. Fish were carried in 9-L polyethylene sacks at a density of 1 fish per 3 ml water. The air space in each sack was enriched with oxygen and the sacks were packed in ice in an insulated box during the journey. At Lake Gallienne, where the helicopter could land, alevins were released slowly from a boat; care was taken to distribute them as much as possible in shallow water and to mix gradually the transport and lake water. At the other lakes, alevins had to be released quickly from the floats or skids of the helicopter. In Lakes Randin and Head, planting was over deep open water because planting sites were dictated by the requirements of the pilot. In Crosskey Lake, planting was achieved over shallow water. Table 3 gives the dates and numbers of alevins released into each lake.

Soon after release alevins were recaptured in Lake Gallienne by means of "night-fishing" with

TABLE 3—Numbers of alevins and release dates in the four study lakes

Year	Gallienne	Randin	Crosskey	Head
1970	93 000 10 June	31 200 12 June	—[1]	—
1971	—	—	—	—
1972	24 500 16 June	—	42 000 16 June	17 500 16 June
1973	50 500 22 June	16 500 22 June	16 500 22 June	16 500 22 June
1974	16 500 2 July	—	—	—
Total	184 500	47 700	58 500	34 000

[1]A dash indicates no planting.

the use of 300-candle-power lanterns, hand nets, and hand seines. Collections were made fortnightly from 21 July to 23 August 1973 in the lower section of Randin Creek. In 1974, weekly collections were made in Randin Creek and on a rocky beach in Lake Gallienne between 21 July and 24 August.

Nylon gillnets, 7.6 × 1.5 m monofilament and 45.7 × 1.5 m multifilament, were used to retrieve yearling and older fish. Stretched mesh sizes of the monofilament nets were 13, 19, 25, and 38 mm and of the multifilament nets 38, 51, 64, 77, 90, 103, and 116 mm. Most nets were bottom-set from shore to a maximum depth of 9 m. Lackey (1970) has shown that Atlantic Salmon are to be found in this depth stratum when they are living in lakes. In Lakes Gallienne and Head, the nets were rotated to ensure that all netting locations were fished by all sizes of net; nets were not rotated in Lake Randin. In Crosskey Lake, the same pattern of net distribution was used in August and September to simplify a tentative population estimate. The fishing effort for 1973 and 1974 is summarized in Table 4. Trap nets were tried, but were withdrawn owing to lack of suitable setting sites, ineffectiveness of the traps, and isolation of some of the lakes.

To monitor possible smolt movement from Lake Gallienne, two barrier traps were constructed in Gallienne Creek during 1973. One, 800 m downstream from the lake, was operational from 11 June; the other, 350 m downstream from the lake, from 13 June. Surface water temperature in the lake was 8°C at this time. Both traps were operated until 23 August. In 1974, only the 350-m trap was operated from 15 June when the lake surface water temperature had reached 10°C. This trap was removed on 22 August.

Data collected from retrieved fish included fork length (mm), weight (g), scales, and stomachs. Stomachs were preserved in 5% formalin and later opened to remove the contents of the cardiac portion. Food items were identified to family, and diet was described using the "frequency of occurrence" method.

Results

Preliminary gillnet samples in 1971 and 1972 led to considerable optimism about the success of alevin planting in Lake Gallienne. In 1971, 82 fish were captured with 218 net-h of effort between 26 July and 26 August. The average size of these 1+-fish was 168 mm (range 117–272 mm). The following year, 31 fish collected in June, aged 2+, averaged 202 mm and four fish taken in August averaged 325 mm (range 115–376 mm). Total effort was 230 net-h. The more detailed follow-up work in 1973 and 1974, however, showed that the initial optimism was not warranted, at least where survival was concerned. Gillnet captures were always sporadic and meagre regardless of frequent rotation and adjustment of the nets. Table 5 summarizes monthly fishing effort, catch, and catch per unit effort in the four experimental

TABLE 4—Net details of retrieval operations in the four study lakes during June–September 1973–1974

Year	Lake	Number of nets	Number of locations	Net size[1] (mm)	Total time (h)
1973	Gallienne	15	36	13–103	4500
	Randin	7	7	25–51	777
	Head	11	14	19–38	914
1974	Gallienne	10	15	38–116	2550
	Crosskey	8	8	38–64	728

[1]Stretched mesh in 13-mm intervals beyond 38 mm.

TABLE 5—Monthly effort, catch, and catch per unit effort (CUE) in the four study lakes during 1973–1974

Lake	Effort (net-h)				Catch (number)				CUE (fish·net-h^{-1})			
	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.
Gallienne												
1973	220	516	3186	—	0	26	51	—	0.00	0.05	0.03	—
1974	576	734	1053	—	1	37	90	—	0.02	0.05	0.08	—
Randin												
1973	—	777	—	—	—	0	—	—	—	0.00	—	—
Head												
1973	—	—	914	—	—	—	0	—	—	—	0.00	—
Crosskey												
1974	—	—	440	288	—	—	97	23	—	—	0.22	0.08

lakes during 1973 and 1974; one net-hour represents one unit of effort. Accurate estimates of the numbers of salmon remaining in the lakes were impossible because failure of the trap nets precluded any marking experiment and because gillnet returns revealed no pattern to which a catch statistics method could be applied. One possible exception was Crosskey Lake in 1974 where, when the data for August and September catches were used and the Leslie method outlined in Ricker (1975, p. 150) was applied, the population of salmon remaining in the lake was tentatively estimated at 106 yearlings and 51 two-year-olds. It should be noted that the water temperature had fallen to 8°C in September, which may have biased the results, and 127 fish were removed from the lake during sampling. All indications are that few salmon remained in any lake and perhaps no fish were left in Lakes Randin and Head.

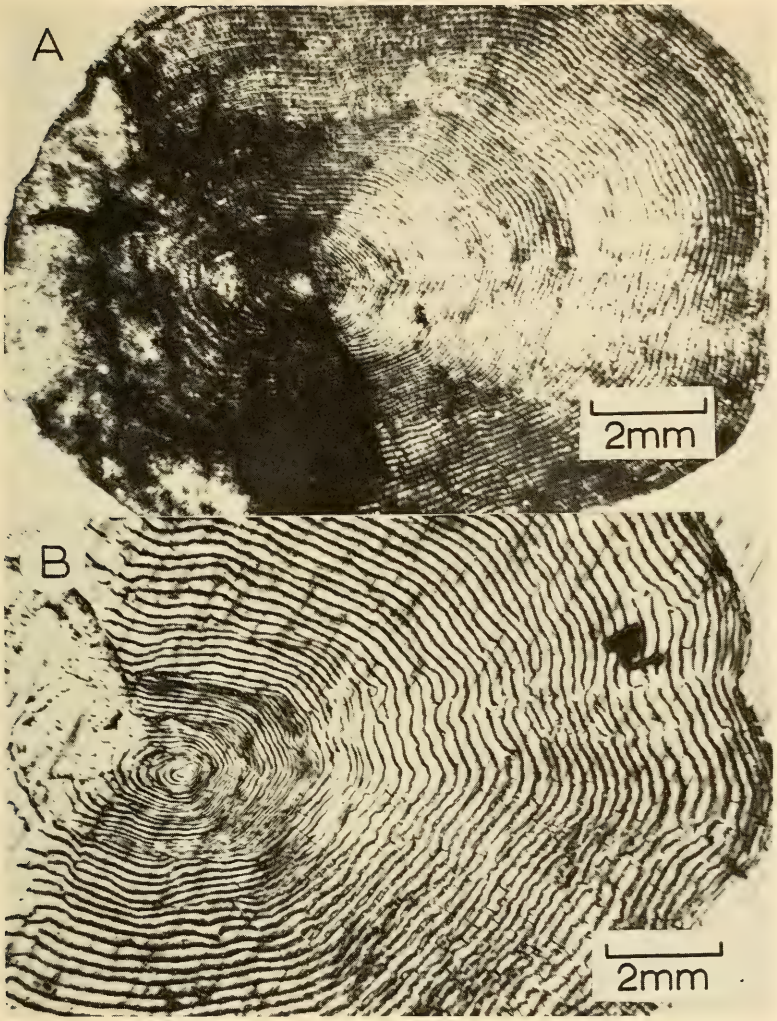
Scales from all sampling years (1970–1974) were used to describe the growth of 322 fish recovered from Lake Gallienne and 120 from Crosskey Lake. Interpretation of the scales was easy. Figure 2A shows a typical scale of a 3+ fish (1970 planting) from Lake Gallienne. The early years of growth on such scales can readily be distinguished from the parr growth of Matamek River fish (Figure 2B). The freshwater zone of the sea-run fish (comprising three years of growth) is equivalent in size to the first-year zone of the Lake Gallienne salmon. Planted fish that have spent at least the first year in fishless lakes can readily be separated from wild stock from the Matamek River.

Growth of alevins during the first summer after planting was analyzed using mean fork lengths of samples retrieved from Randin Creek and Lake Gallienne. Growth was linear over the summer and can be described by the following equations:

Randin Creek 1973 $y = 24.3 + 0.53x$
Randin Creek 1974 $y = 24.7 + 0.54x$
Lake Gallienne 1974 $y = 25.8 + 0.67x$

where y = fork length (mm) and x = days past planting. These equations convert to growth rates of 0.53 mm·d^{-1} and 0.54 mm·d^{-1} in Randin Creek during 1973 and 1974 respectively and 0.67 mm·d^{-1} in Lake Gallienne. Annual growth of older fish in Lakes Gallienne and Crosskey is shown in Figure 3. These curves are based on fish retrieved in August and September from Crosskey Lake (length-age relationship was the same for the two sampling periods) and recaptures between June and September of the 1970 year class in Lake Gallienne; the 1970 year class data from Lake Gallienne provided the most complete results, but growth of fish planted in other years was similar. The mean condition factors ($\bar{K}$) of the fish calculated for different life history stages are given in Table 6.

Analysis of the diet of first-summer fish taken in Randin Creek (July–August) showed chironomid larvae and imagos to be the most important components. Baetid nymphs and daphnids were also consumed throughout the summer, but to a lesser extent. Other organisms appeared occasionally in the diet. In the lake, chironomids were replaced by chaoborid larvae; cladocerans were also important particularly in July when polyphemids and daphnids were occasionally predominant. The diet of the older fish in Lakes Gallienne and Crosskey is summarized in Table 7. Chaoborid larvae were always the major food item in both lakes. Other items were periodically important, but their



A, Lake Galienne salmon (fork length, 483 mm) showing three annulae indicating an age of 3+.

B, Matamek River salmon (fork length, 510 mm) showing three freshwater annulae and one seawater annulus indicating a total age of 4+.

FIGURE 2. Scales of Atlantic Salmon from the Matamek River system.

appearance in the diet probably indicates only the opportunistic nature of salmon feeding behavior. Negligible surface feeding occurred. All stomachs containing food (over 80%) were filled to distension.

In the lake environment, recognition of life history stages, parr, smolt, and adult, presents some difficulties particularly as dead fish tend to revert to a more parr-like appearance. It was important for this study to recognize, if at all

TABLE 6—Mean condition factors ($\overline{K}$)[1] of salmon at various life stages in Lake Gallienne and Crosskey Lake

	Galienne (July–Aug.)			Crosskey (Aug.–Sept.)	
	Parr	Smolt	Adult	Parr	Adult
Number	36	31	10	60	61
$\overline{K}$	1.60	1.46	1.16	1.41	1.17
Standard deviation	0.32	0.20	0.16	0.07	0.13

[1] $\overline{K} = I/N \Sigma\left(\frac{W \times 10^6}{L^3}\right)$; W = weight in grams, L = fork length in millimetres, N = number of fish in sample.

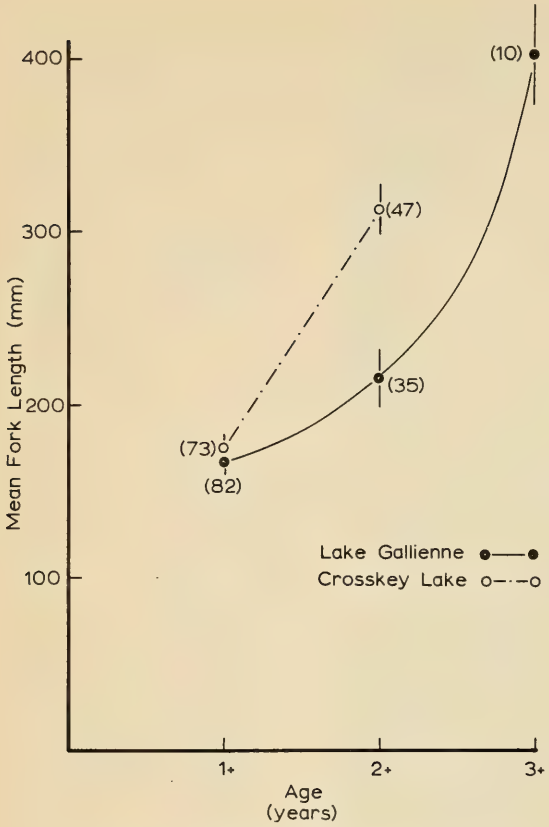


FIGURE 3. Growth of salmon in Lake Gallienne (1970 year class) and Crosskey Lake. Numbers in parentheses are sample sizes. Vertical bars are 95% confidence intervals.

possible, these stages because true migration, as distinct from dispersal, could be expected only at the smolt stage. During 1973 and 1974, 35 smolts (mean fork length, 183 mm) were caught during July in Lake Gallienne; all were yearlings. In August 1973 and 1974, we took 44 yearlings (mean fork length, 194 mm) of smolt-like appearance, having a definite silver sheen and dark fins, but with faint parr bars and red spots. No smolts were taken from Crosskey Lake, but this could have been because fishing had been done late in the summer. Eleven out of 73 yearlings taken from Crosskey Lake were classified as adults on the basis of external appearance. These were very large (mean fork length, 235 mm). All 2+ fish from Crosskey Lake were adults. In Lakes Gallienne and Crosskey, all fish possessd only immature gonads.

No evidence of migration of smolts was obtained during the study. No salmon were captured in the barrier traps in Gallienne Creek, but the effectiveness of the traps in capturing fish was verified by the frequent capture of resident brook trout (*Salvelinus fontinalis*) below the escarpment. In 1974, the trap operated throughout a large spring spate which occurred at water temperatures ideal for smolt migration (10°C)

The scales of anadromous salmon returning to the Matamek River since 1972 (the first possible year for returns as 1+ smolts and one-sea-winter fish from the 1970 plantings) were examined for the characteristic growth patterns of the lake fish, but none was found in 154 samples.

Discussion and Conclusions

The number of salmon alevins that survived transport and were able to establish themselves in the fishless lakes was very low. In the two lakes where planting was done over deep water, Randin and Head, no survivors were retrieved. The problem of survival does not appear to be related to the suitability of the lakes as habitat, for they all conform to criteria known to be suitable for Atlantic Salmon (see e.g., Havey and Warner 1970; Cooper 1940) and the few survivors grew exceptionally well. It was evident that the alevins were exhausted and disoriented after the long journey from Tadoussac. Experiments conducted to investigate the extent of their debility showed greatly reduced

TABLE 7—Diet composition of yearling and older salmon in Lake Gallienne (July–August 1973–1974) and Crosskey Lake (August–September 1974). Numbers indicate % occurrence

	Gallienne	Crosskey
Insecta		
Chaoboridae larvae	59.90	62.00
pupae	0.01	0.00
Corixidae adults	39.50	25.20
Baetidae nymphs	12.30	0.05
Phryganeidae larvae	0.03	0.03
adults	0.03	16.80
Libellulidae nymphs	0.02	0.03
Aeshnidae nymphs	0.02	0.04
Coenagrionidae nymphs	11.30	41.20
Ephemeridae larvae	0.02	0.01
Notonectidae adults	0.02	0.03
Crustacea		
Daphnidae adults	0.01	11.20
Empty	9.00	0.04
Number of fish	195	107

buoyancy and pronounced sounding behavior (Rimmer 1975). It is quite possible that the alevins released over deep water vanished into the depths where cold temperatures (< 4°C) would halt normal activity (Allen 1941) and great pressure caused mortality (Bishai 1960). The use of highly sensitive echo-sounding equipment may be the easiest way of clarifying the uncertainties of post-planting survival.

The outstanding growth of the fish in this fishless habitat is evident when compared with data in the literature, most of them from more temperate environments where growth conditions could be expected to be better. Allen (1941) recorded a growth rate for young-of-the-year of 0.40 mm·d^{-1} for Halkirk Burn and 0.38 mm·d^{-1} for the River Eden, both figures much less than those for Randin Creek (0.53 and 0.54 mm·d^{-1}) or Lake Gallienne (0.67 mm·d^{-1}). Rapid growth continues, resulting in 3+ fish in fresh water that are not much smaller than one-sea-winter fish of wild Matamek stock. A comparison of this growth with that of selected introduced and wild populations is provided in Table 8. Even fish planted as alevins in fishless lakes in Wales, which grew much faster than natural stocks (*c.f.*, Table 8), did not grow as fast as the fish in the present study.

The rapid growth of the fish in the Matamek lakes may be explained in part by the absence of interspecific and low intraspecific competition because of the low density of survivors. Higher densities of fish in the lakes would eventually suppress the growth rate as food resources became limiting. The most striking feature of the results is the enormous growth potential of young Atlantic Salmon which, even in a relatively severe physical environment (as the North Shore of the Gulf of St. Lawrence must be considered), can be expressed in the absence of competition and with suitable food. Chaoborid larvae provide the bulk of the diet of fish beyond the alevin stage and these were present in the lakes in very high densities. Pope et al. (1973) recorded densities of 477/m^2 in Lake Gallienne and 979/m^2 in Crosskey Lake. Planktonic organisms were apparently sufficient to satisfy the food requirements of the salmon because very little surface-feeding occurred. On this planktonic diet the fish grew very fat and $\overline{K}$ factors (Table 6) far exceeded those of wild populations which, except for maturing male parr, are usually close to unity (Hoar 1939; Power 1969).

No evidence of smolt migration was found during the study. The presence in Lake Gallienne of large fish bearing an appearance intermediate between parr and smolt during August suggests that these fish were smolts earlier in the year, but had not migrated. Evropeitseva (1962) has reported smolts reverting to their parr livery if they did not go to sea shortly after smoltification. It is not uncommon when rearing salmon in fishless lakes to have some fish become residual, but it appears rare that all should stay. In Loch Kinardochy, 4.47% of the 1965 planting and 41.85% of the 1967 planting failed to migrate (Harris 1973). Jones and Evans (1962) found post-smolts up to the age of 6+ in Llyn Dyrnogydd, but apparently most fish

TABLE 8—Age-group lengths (mm) of young salmon of various origin from selected bodies of water

Location	Originally fishless	Salmon origin	Age 1+	2+	3+	4+	Source
Lake Gallienne, Quebec	Yes	Introduced	168.3	216.7	404.1	—	This study
Crosskey Lake, Quebec	Yes	Introduced	176.9	313.3	—	—	This study
Llyn Cilan, Wales	Yes	Introduced	113.7	—	—	—	Sinha and Evans (1969)
Llyn Dyrnogydd, Wales	Yes	Introduced	136.0	165.0	201.0	—	Jones and Evans (1962)
Llyn Teyrn, Wales	Yes	Introduced	104.0	158.0	—	—	Jones and Evans (1962)
Lough Knader, Ireland	No	Introduced	43.7	119.8	191.0	—	Hewetson (1963)
Gambo Pond, Newfoundland	No	Ouananiche	80.0	157.0	205.0	322.0	Leggett and Power (1969)
Terra Nova River, Nfld.	No	Ouananiche	99.0	113.0	176.0	216.0	Andrews (1966)
River Forss, Scotland	No	Sea-running	112.0	129.0	—	—	Frost (1950)
Sinclair Burn, Scotland	No	Sea-running	88.0	107.0	—	—	Allen (1941)
Breivikelva, Norway	No	Sea-running	74.0	99.0	109.0	124.0	Power (1973)
Matamek River, Quebec	No	Sea-running	77.0	113.0	133.0	—	Schiefer (1969)

migrated from the lake at age 2+ or 3+. Berg (1967) has reported residual salmon in Norwegian lakes, some even showing evidence of spawning. The critical question here is: what causes residual behavior? Is migration blocked because suitable stimuli are not present in the lakes or do the fish resemble smolts morphologically without being physiologically metamorphosed? If migration is somehow connected with a requirement for greater food resources to support greater growth, increasing the density of fish in the lakes by improving survival should induce migration.

If the potential of fishless lakes as rearing areas for salmon smolts is to be realized, answers to the above questions are needed. It is also apparent from our own experience that much more needs to be known about factors that influence the mortality of alevins both during transport and after planting in a lentic environment. An increase in survivorship is the prime problem to be overcome if this management technique is to be developed.

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Species-area Relationships for Vascular Plants of Some St. Lawrence River Islands

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McNeill, J. and W. J. Cody. 1978. Species-area relationships for vascular plants of some St. Lawrence River islands. Canadian Field-Naturalist 92(1): 10–18.

A detailed survey has been made of the vascular plant species on each of the 17 islands and one mainland area of the St. Lawrence Islands National Park, Ontario. In a comparison with the area of each island the number of species was found to give a close and almost equally good fit to both the semi-log and the power function models, as well as to a curvilinear modification of the former. Gordon Island, which differs from the others in its sandstone substrate, is somewhat richer in species than predicted by the semi-log regression. A comparison with similar data from limestone islands in Lake Ontario suggests that the latter may show greater species diversity, but a significant difference is not established. From the power function fit, the St. Lawrence River islands appear floristically as segments of a continental area with isolation playing little or no part in determining species composition. This is discussed in terms of extinction/immigration theories of island biogeography.

Key Words: island biogeography, species diversity, St. Lawrence Islands National Park, Ontario.

As part of a phytogeographic study of the St. Lawrence Islands National Park, Ontario, a detailed survey of the vascular plant species composition of the 17 islands and the one mainland area of the park (Figure 1) was completed in 1975 by Cody (Report to Parks Canada by W. J. Cody 1976). This was an extension of earlier studies conducted by staff and students of the Biology Department, Queen's University, Kingston between 1966 and 1974 (Reports to Parks Canada by R. E. Beschel 1970; A. Crowder and A. E. Garwood 1971; J. W. Johnson 1974), and, prior to 1966, by W. G. Dore of the Plant Research Institute, Canada Department of Agriculture. The species occurrence data obtained (Table 1) were analyzed in terms of models of relationship between the size of a particular area and the

TABLE 1—Area and number of vascular plant species recorded from the islands and mainland of the St. Lawrence Islands National Park

Island	Area (A) (ha)	$\log_e A$	Number of species (S)	$\log_e S$
1. Adelaide	5.30	1.6681	251	5.5255
2. Aubrey	5.79	1.7556	197	5.2832
3. Beaurivage	4.38	1.4777	218	5.3845
4. Camelot	9.47	2.2481	221	5.3982
5. Cedar	9.31	2.2309	256	5.5452
6. Constance	2.95	1.0832	161	5.0778
7. Endymion	4.41	1.4841	208	5.3376
8. Georgina	9.43	2.2439	249	5.5175
9. Gordon	6.27	1.8363	280	5.6348
10. Grenadier*	437.82	6.1613	500	6.2146
11. Mallorytown	38.04	3.6386	288	5.6630
12. McDonald	14.17	2.6506	269	5.5946
13. Mermaid	1.54	0.4305	116	4.7536
14. Milton	3.24	1.1750	199	5.2933
15. Mulcaster	5.38	1.6833	246	5.5054
16. Squaw	3.05	1.1154	210	5.3471
17. Stovin	4.13	1.4178	180	5.1930
18. Thwartway	36.45	3.5960	289	5.6665

*Data on area and species refer to the entire island, although only a portion of the island is in the national park.

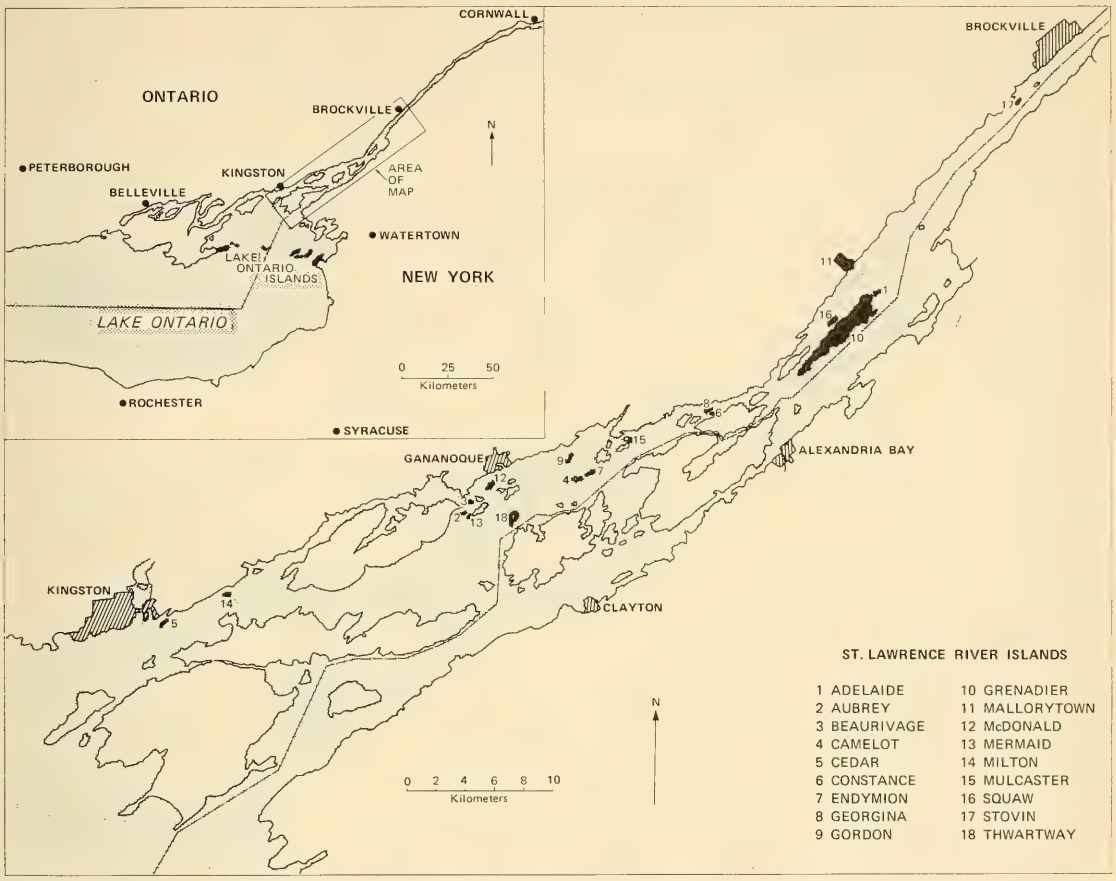

FIGURE 1. Map of the upper portion of the St. Lawrence River showing the positions of the areas whose species composition was studied. The inset map shows the position in relation to Lake Ontario and to the Lake Ontario islands studied by Hainault (1968). The numbers are those given to the islands in Table 1.

number of species occurring within it. This was done in order to explore a number of questions regarding the ecology and biogeography of these islands, both as a group and in relation to other studies of island biogeography (MacArthur and Wilson 1967; Simberloff 1974).

There are five main questions. (1) Do the species-area relationships suggest that the islands form a homogeneous group or are any significantly different from the others? (2) Which of the possible models of species-area relationship shows the best fit to the data? (3) What conclusions regarding the ecology and floristic richness of the islands are suggested by fitting these models? (4) Do any differences emerge in comparisons with species-area relationships among the nearby Lake Ontario islands with a basically similar flora but on a limestone rather than granitic substrate? (5) Does the mainland area in the survey show any differences from the islands that might be interpretable in terms of island biogeographic theory?

Most data on the occurrence of animal species are based on counts of the number of individuals of each taxon present in a given area; such information cannot usually be obtained, however, for plants. Instead, in order to use models of species distribution such as the logarithmic series (Fisher et al. 1943) or the log-normal (Preston 1962), it is necessary to assume that the number of "individual plants" occupying a given area is proportional to that area. This is plausible only if the areas concerned are all within the same ecological association, or

comprise similar sets of associations. The St. Lawrence River islands probably satisfy the second condition although the amount of logging, farming, and other human interference has varied from island to island.

Species-area Models

Two main models were tested. The first is based on the assumption that the logarithmic series expresses the frequency curve of the number of species containing increasing numbers of individuals (Williams 1964, Chapter 4). It has been found empirically that if the number of plant species in a single homogeneous association is counted in a series of samples (e.g., quadrats), then (except for very small areas) the number of species recorded usually increases linearly as the logarithm of the area sampled (usually expressed as the logarithm of the number of quadrats). The slope of the straight line best fitting the plot of number of species (S) against log area is a measure of the diversity of the particular association. The equation of the straight line can be expressed as $S = \alpha \ln A + D$, where α is the *Index of Diversity*, A the area (or number of equal-sized quadrats), and D a constant that depends on factors such as the plant density of the particular association and the thoroughness with which the number of species has been recorded. Kobayashi (1975) has modified this model so that the relationship, although no longer entirely linear, applies even to very small areas. The modified model takes the form $S = \alpha' \ln (1 + A/E)$ where E is a constant that Kobayashi calls the *elemental area* of the particular association; this should not be confused with the *minimal area* of some phytosociologists (a questionable concept (see Goodall 1970)) but is related to the *characteristic area (C)* of an association, as developed by Kobayashi (1974), in that $C = (e + 1) E$.

The second model has generally been found more applicable to large areas with a diversity of associations and environments (Williams 1964, Chapter 5; MacArthur and Wilson 1967, Chapter 2). Here the number of species (S) of any one group of organisms may be related to the area (A) according to the equation $S = CA^z$, which can be expressed as $\log S = z \log A + \log C$. Thus there is a linear relationship between the *logarithm* of the number of species and the logarithm of the area. This relationship has been applied extensively to island biogeography and the values of z determined empirically are reasonably consistent with the theoretical value of 0.27, calculated under the assumption that the frequency curve of species containing various numbers of individuals is log-normal (Preston 1962). Where the areas being studied are samples of increasing size from the same island or from a continental region, values of the constant z are usually much lower: 0.12–0.17 as against the common range of 0.20–0.34. The constant C, like D (above), is a function of population density and varies widely with the type of organisms involved and the biogeographic region of the world.

Species/Log Area Model

Although each of the St. Lawrence River islands comprises more than one ecological association they are sufficiently small and topographically uniform for it to be worth applying the first model to them. Figure 2 shows the number of species recorded from each (up to 1975) plotted against the natural logarithm of the area of each island; it also shows the fitted regression line ($Y = 57.0\ X + 121.0$; where $Y = S$ and $X = \log A$) and the 95% prediction limits (Sokal and Rohlf 1969) about that line. The coefficient of determination (r^2) is 0.88 and the standard deviation about the fitted line ($s_{Y.X}$) is 28.47; these values represent a particularly good fit. For example, although Diamond and Mayr (1976) quote an $r^2 = 0.98$ for bird species data from the Solomon Islands, this refers only to the "nonisolated" islands. The value for all 50 islands is $r^2 = 0.85$; with $S = 39.4$, their $s_{Y.X} = 9.09$ gives a coefficient of variation (V) of 23.1 as against 11.8 for this St. Lawrence River islands fit. The corresponding figures for the plant species data of Johnson et al. (1968) from the California coast islands are $r^2 = 0.60$ and $V = 58.3$ ($s_{Y.X} = 122.5$ with $S = 210$).

For the St. Lawrence islands data all points fall within the 95% prediction limits of the regression ($\overline{S} = 183$ to 299 at $\ln \overline{A} = 2.1053$). Gordon Island, however, does not fit the linear relationship postulated as well as do the others. This suggests that the assumption of ecological homogeneity may not be valid for it and indeed Gordon, an island with low relief, is the only one with a sandstone substrate, all the others being granitic. If Gordon is excluded from the analysis

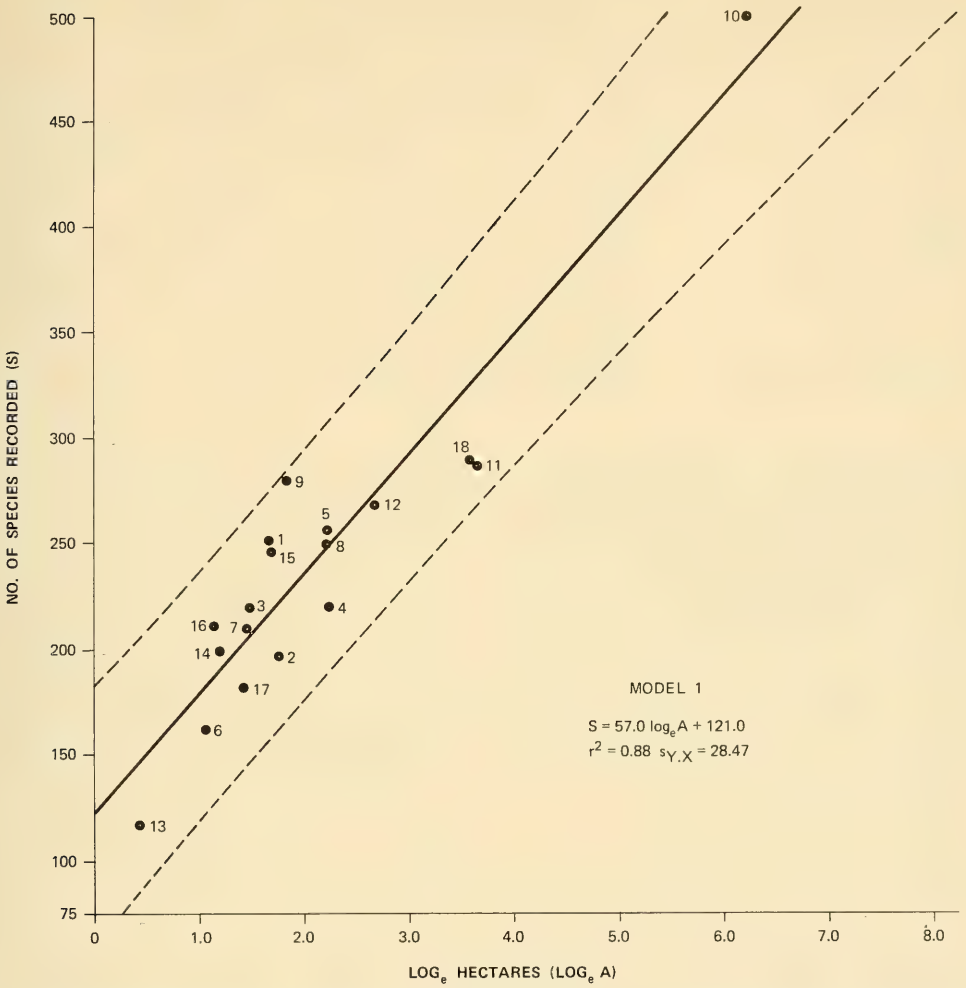

FIGURE 2. Number of species (S) plotted against the natural logarithm of the area ($\log_e A$) for the St. Lawrence River islands. Regression line of S upon $\log_e A$ is fitted; broken lines indicate the 95% prediction limits of species number based on the regression equation. The numbers are those given to the islands in Table 1.

the position and slope of the regression line ($y = 57.5x + 116.7$) are little changed, but it provides a rather better fit ($r^2 = 0.91$; $s_{Y.X} = 25.63$). Because the probability upon which prediction limits are based is that of an additional observation belonging to the set for which the regression has been calculated, it is legitimate to compare the number of species on Gordon Island with the prediction limits of the new regression for an island of that size. The 95% prediction is for 166 to 279 species whereas 280 species are recorded from Gordon. On the other hand, the mainland area round Mallorytown Landing, and Thwartway, the least disturbed island, are both somewhat species-poor. Even when removed from the analysis, however, they remain within the 95% prediction limits based on the regression line of the other islands.

By treating the sandstone substrate of Gordon Island as an 'effect' in a hierarchical analysis of variance, the significance of the resultant increase in the variance accommodated by the regression was explored. The F value obtained (2.70 for 1 and 15 degrees of freedom) is not, however, significant at the 10% level.

The index of diversity (α) for the apparently homogeneous group of 17 areas with a granitic substrate is 57.5 with 95% confidence limits of 47.3 to 67.7. Although indices calculated for *single* associations in arid land in New South

TABLE 2—Area and number of vascular plant species recorded from islands and land areas in eastern Lake Ontario (data from Hainault *op. cit.*)

Island	Area (A) (ha)	$\log_e A$	Number of species (S)	$\log_e S$
19. Long Point	1055.5	6.9618	467	6.1463
20. Timber	46.2	3.8330	221	5.3982
21. Swetman	35.0	3.5554	156	5.0499
22. Main Duck	208.0	5.3375	377	5.9323
23. Yorkshire	20.6	3.0253	201	5.3033
24. Galloo	809.8	6.6968	360	5.8861
25. Little Galloo	19.5	2.9704	73	4.2905
26. Calf	15.6	2.7473	132	4.8828
27. Stony	566.4	6.3393	368	5.9081
28. Stony Point	1700.5	7.4413	450	6.1093

Wales range from 4.8 to 6.2 and in alpine valleys in Switzerland from 3.4 to 12.1 (see Williams 1964), those reported by Curtis (1959, p. 517) for forest communities of Wisconsin are very similar to those found in this study and range from 40.1 to 70.4. Although partly a reflection of real difference in species diversity (e.g., in the higher alpine habitats in Switzerland), the discrepancies in the index values are largely due to the islands and the Wisconsin forest communities comprising *several* associations. The highest reported index of diversity for plant species is 114.2 from a Malaysian rain forest community (Poore 1968; Lamont et al. 1977).

Species/Log Area Model (Kobayashi Modification)

Kobayashi's (1975) modification of the species/log area model can readily be fitted by an iterative procedure using the value of α already calculated as a first approximation of α' and $e^{-D/\alpha}$ as that of E; the formula of the resultant best fit to the 17 areas with granitic substrate is $S = 58.2 \ln(1 + A/0.1415)$; this was confirmed by a least-squares non-linear regression (Hartley 1961). This formulation has the merit of the regression passing through the origin (no species at zero area) and is almost as good a fit as the other ($s_{Y.X} = 25.67$). The characteristic area, which Kobayashi (1974) interprets as the unit size of sampling, is about 0.24 ha.

Using the Kobayashi model, it is possible to compare the St. Lawrence River islands with eight islands and two adjacent land areas in eastern Lake Ontario for which data were gathered by Hainault (1968) (see Table 2). At their closest, the Lake Ontario islands are only some 30 km to the south-west, but they are on a limestone substrate. The absolute numbers of species recorded by Hainault are much lower per unit area than those for the St. Lawrence islands, but these data are not directly comparable because Hainault's survey was carried out in a single season with only one or a few days on the smaller islands.

Assuming that the relative thoroughness of Hainault's survey was about the same for each of his islands, the slope of a Kobayashi fit to these data can be compared with that obtained for the St. Lawrence islands (Figure 3). The best fit for the Lake Ontario data is when $S = 73.9 \ln(1 + A/3.182)$; the deviation associated with this fit ($s_{Y.X} = 47.26$) is much greater than that for the St. Lawrence islands. This does not seem to be explicable by any features of the islands and land areas themselves, but rather reflects the incompleteness of the survey. For example the characteristic area is 5.5 ha, greater than the size of many of the St. Lawrence islands.

The higher index of diversity of the Lake Ontario islands (73.9 against 58.2) appears to agree with the common experience that, under cool temperate conditions, limestone habitats show greater diversity of species than do those on acid soils. An analysis of variance, however, shows that, when account is taken of the differences in the relative positions of the two curves (the E values), the additional variance accommodated by separate indices of diversity is not significant at the 10% level (F-value 2.46 for 1 and 23 degrees of freedom). The available data are, therefore, inadequate to justify the suggestion that the Lake Ontario islands are floristically more diverse; more intensive ex-

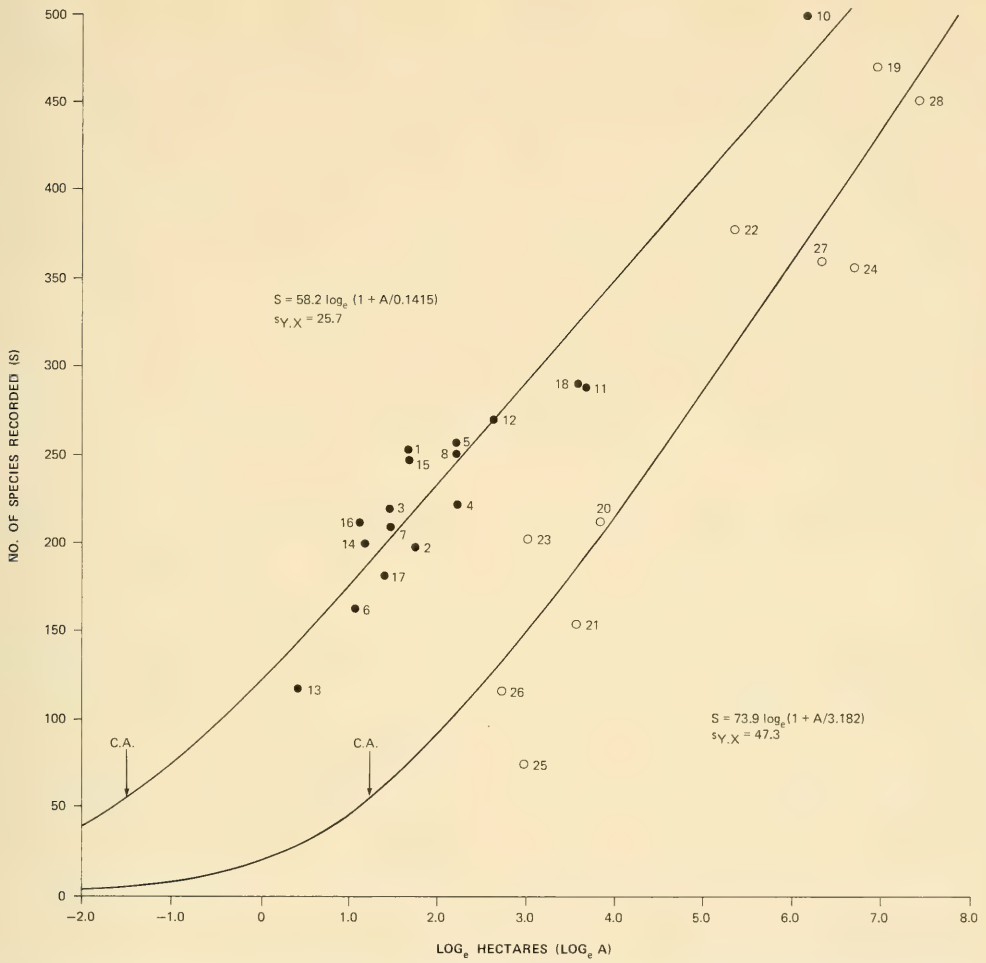

FIGURE 3. Number of species (S) plotted against the natural logarithm of the area ($\log_e A$) for the St. Lawrence River (●) and Lake Ontario (○) islands. Least squares regression equation $S - \alpha \log (1 - A/E)$ are fitted for the two sets of islands. The characteristic areas indicated by the two regressions are marked (CA). The numbers are those given to the islands in Tables 1 and 2.

ploration of these islands is needed to confirm or reject this. The single index of diversity for the two sets of islands combined is 66.0.

Power Function Model

Applying the second model to the St. Lawrence River islands (Figure 4), the non-linear power function regression explains almost as much of the variance in species number as does the linear semi-log regression ($s_{Y.X} = 28.3$). Gordon Island again appears unusually species-rich, but in this plot Mermaid Island (number 13) is identified as being markedly species-poor. This appears to be a reflection of its absolute size being so small that the number of possible habitats is restricted to a greater extent than is predicted by its relative size (i.e., this model is not applicable to such small areas as Mermaid Island). The least squares fit for all 18 areas is $S = 158\ A^{1.19}$. This is plotted by the upper curve in Figure 4, which suggests that Grenadier, the one very large island, may be dominating the regression. If this island is omitted, however, the resultant regression equation ($S = 160\ A^{0.18}$) is almost identical to that calculated for all areas. The two regression curves are represented, on an expanded area scale, by the two lower curves in Figure 4.

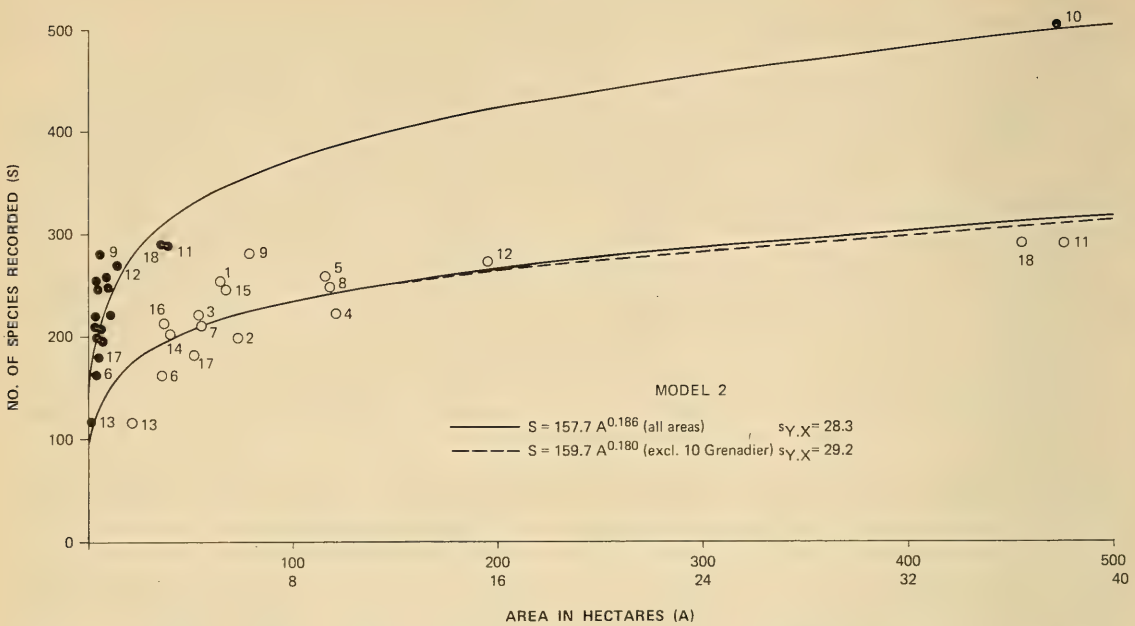

FIGURE 4. Number of species (S) plotted against the area (A) for the St. Lawrence River islands. Least squares regression curves of the power function of A are fitted. The solid line curves are based on all 18 areas; the broken line is the regression curve with number 10, Grenadier Island, excluded. The upper and lower curves correspond to the upper and lower A scales marked on the abcissa. The numbers are those given to the islands in Table 1.

Discussion

Exploring these species-area relationships has answered some questions and left others open to further study.

The areas in the St. Lawrence Islands National Park in general form a homogeneous set of vascular plant associations. The one possible exception is Gordon Island, which is somewhat richer in number of species than would be predicted by its size. Our surveys were in no way biased towards species recording on Gordon Island and so it would be of particular interest to see whether this characteristic is borne out by data from other groups of organisms.

Williams (1964) concluded empirically that the power function model (model 2) rarely applied in areas below about 1 km^2 while the semi-log model (i.e., species/log area) was the most appropriate for single associations ranging from a few square metres to hundreds of square kilometres. Kilburn (1966) has questioned this on the basis of observations on prairie and forest plots in Illinois and Wisconsin and of a re-examination of Hopkins' (1955) data from various communities in Britain. Both Hopkins' and Kilburn's data combined species numbers for vascular plants with those for various groups of non-vascular plants. By disentangling the species numbers in each taxonomic group (albeit speculatively) Kobayashi (1975) succeeded in obtaining a closer fit for these data to his modification of the semi-log model than that obtained by Hopkins (semi-log) or Kilburn (power function). The St. Lawrence islands data cannot be adduced as evidence in favor of one of these possibilities over the others as they fit all three almost equally well. This is not altogether unexpected. The islands comprise more than the single association specified for the strict application of the semi-log model, yet they are not as diverse as the larger islands to which the power function model regularly applies. Moreover, the data are confined to one group of organisms.

The concept of species diversity as a function of the slope of the species/log area regression (α) rather than the absolute number of species recorded requires comment. Whittaker (1972) and Peet (1974) discuss concepts of diversity pointing out the practical problems of developing a direct measure of species number per unit area that will be comparable from one study to another. Slope measures are comparable but

their interpretation in terms of species diversity depends to some extent on the model being used. For a species/log area curve obtained from successively greater areas of the same association, the slope is a measure of relative species diversity ('richness' in Peet's (1974) terminology) in that the mean number of individuals per species must be lower with a steep slope than with a gentle one, i.e., the likelihood of any two plants within a given area being of a different species is greater.

The index of diversity calculated from the semi-log model for the St. Lawrence River islands gave 95% confidence limits of 47–68. The similarity with the values calculated from forest stands in Wisconsin suggests that the floristic diversity of the islands is comparable with that of other similar areas, and that they are neither notably species-rich nor notably species-poor. The suggestion that the Lake Ontario islands with a limestone substrate may have greater species diversity could not be confirmed with the available data; more extensive collecting on that group of islands is required.

Most zoogeographic studies of islands seek to interpret species numbers in terms of equilibria between rates of extinction and immigration (Simberloff 1974). The applicability of the concept of regular extinction and recolonization in ecological time is difficult to conceive for most perennial vascular plants, whether trees or herbs. Many such "individuals" may have a life span of hundreds if not thousands of years (see, for example, Harberd 1961, 1962, 1967) and extinction is more plausibly a function of the destruction of particular habitats than one directly related to species density. In such cases, recolonization is likely only if the habitat is in some way re-established. There are, of course, vascular plant species, mostly annual, for which the extinction–colonization pattern is the rule, but in the St. Lawrence islands such species make up little more than 10% of the total flora.

Although there are notable exceptions, such as the experimental work on mangrove islands by Simberloff and Wilson (Simberloff 1976a, b), many zoological studies appear to equate extinction with the failure to record a species in a particular survey. The ease with which even experienced collectors, searching appropriate habitats, can overlook an immobile vascular plant species makes this seem a highly questionable assumption. Like many of the published botanical data on species presence (e.g., Johnson et al. 1968; Johnson and Raven 1973), our data represent observations accumulated over several years. Moreover, our data are unusually complete because the relatively small areas involved have been intensively studied by several workers over a number of years and all the voucher specimens have been available to us. Nevertheless, the rate of accumulation of records and further work since the completion of the second author's survey leads us to believe that the records for each island are only around 95% complete. If extinction and recolonization are factors at all, they are likely to operate on the rarest species, the very ones that may be overlooked in even the most thorough surveys.

The value of the constant z in the power function model is regarded as an indicator of relative rates under the extinction–immigration hypothesis (MacArthur and Wilson 1967). The value of z obtained from the St. Lawrence River islands is substantially and significantly lower (95% confidence limits of z: 0.16–0.22) than the theoretical value of 0.27 calculated under the assumption of a log-normal distribution of individuals. Such a departure is generally interpreted in terms of high immigration rates (Diamond and Mayr 1976). The value that we have found, however, is consistent with those obtained by taking samples of increasing size from the same island or from a continental area, a situation in which there would be an available pool of immigrants just outside the arbitrary area boundary.

On this basis the islands can be looked upon floristically as segments of a continental area with isolation playing little or no part in determining species composition. This would be supported by the fact that Mallorytown, part of the mainland, fits the regression well and does not have more species than predicted for a corresponding insular area. Whether this is owing to the extinction–immigration hypothesis being inapplicable to vascular plant species is difficult to determine because of the proximity of all the St. Lawrence River islands to the mainland or to large islands not included in the survey. An alternative explanation of the z values being significantly less than 0.27 is that

the frequency curve of individuals per species is not log-normal.

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Evaluation of the Winter Range of White-tailed Deer in Point Pelee National Park, Ontario

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The range of White-tailed Deer (*Odocoileus virginianus*) at Point Pelee was studied to determine whether previously reported overutilization was occurring. Plots (256, each 9.3 m²) were established throughout the 4.5-km² deer range. Of the 31 most abundant species of woody plants (non-vine), 18 were browsed. Availability of browse species, measured as stems of woody plant species, correlated with use. On only three of the plots did browsing on any species exceed 33% of available stems. Vines supplemented other woody vegetation as deer browse, and observations of grazing in winter indicated some dependence on herbaceous food. Deer do not appear to be overutilizing any part of their range.

Key Words: White-tailed Deer, Point Pelee, food of deer.

According to Henry (1972, 1975), White-tailed Deer have been reportedly overutilizing their winter food supply over much of the deer range in Point Pelee National Park. Henry's conclusion was based on observations of movements and distribution of deer, not on any analysis of vegetation. I have tested this conclusion by analysis of browse availability and use, and present contrary findings.

Past reports in Parks Canada files and the comments of wardens suggest that the deer herd has not exceeded approximately 25 animals for close to 25 years. In 1951, V. E. F. Solman (unpublished report, Parks Canada, Point Pelee National Park) estimated 25 deer, and commented that food was available to support more deer. In 1956, the herd was reduced by 12 animals (D. Wigle. The deer on Point Pelee. Unpublished report, Parks Canada, Point Pelee National Park). In the winter of 1975–76, the herd consisted of 22 or 23 animals, based on repeated observations of marked and known deer over a period of 3 months (J. B. Theberge and S. M. Oosenbrug. Behaviour and population limitation of White-tailed Deer at Point Pelee. Unpublished report, Parks Canada, Cornwall, Ontario). The density, approximately 5.6 deer/km², is low compared with that of nearby Rondeau Peninsula recently with 19 deer/km² (D. Euler. 1974. An analysis of the recruitment potential of the White-tailed Deer population in Rondeau. Unpublished report, Ministry of Natural Resources, Toronto, Ontario. 3 pp.). The density of deer at Pelee is greater than a mean of 2.1 deer/km² for areas within central Ontario (King 1976).

In this study we set out to determine whether food availability was limiting deer; the limitation would be indicated by overutilization of the winter food supply.

Study Area

The 15.0-km² park is situated on a peninsula that juts out into Lake Erie, in Essex County, Ontario. Most of the park is marsh; the 4.5-km² deer habitat lies primarily west and south of the marsh. The deer habitat is isolated because of intensive agriculture and urbanization north of the peninsula.

Point Pelee's forests are ecotonal between the Great Lakes–St. Lawrence, and deciduous forests (Rowe 1972). A variety of vegetative communities exist, all extensively modified by logging, livestock-grazing, and fishing prior to the establishment of the park in 1918, or agriculture and recreational use since then (Battin 1975). Approximately 120 ha are in early post-agriculture successional stages, with grasses (Gramineae) dominant in the youngest fields and dogwoods (*Cornus* spp.), sumac (*Rhus* spp.), and willow (*Salix* spp.) dominant in older fields. Approximately 41 ha are wet woodlands flooded periodically by high lake levels and dominated by silver maple (*Acer saccharinum*). On former sand dunes and beach ridges are 270 ha of a variety of shrub and tree communities. I subdivided those communities, as did Henry (1972, 1975) into "red cedar forest" and "cedar savanna," both late successional stages dominated by *Juniperus*

virginiana, and also "hackberry forests" consisting of large hackberry trees (*Celtis occidentalis*) and oak (*Quercus* spp.) with a red cedar understory in places. Maycock (1971. An ecological study of the forests of Point Pelee, Essex County, Ontario. Unpublished report, Parks Canada, Point Pelee National Park) identified and mapped this vegetation in detail.

Methods

Field data were collected between 1 May and 30 September 1974, with some additional observations of feeding deer made incidentally to deer behavioural research between 15 January and 15 April 1975.

Transects (32) were established throughout the park, exclusive of marsh, in the five deer habitats. The percentage of the total deer range represented by each habitat, and number of transects in each were as follows: hackberry forest (47%), 15 transects; abandoned farmland (30%), 7; wet forest (10%), 5; red cedar forest (8%), 3; cedar savanna (5%), 2. These proportions were chosen primarily to reflect relative sizes of these habitats, but also to represent, with single transects in each, the more detailed 29 vegetative zones identified and mapped by Maycock (*op. cit.*). The size of the abandoned farmland was greater by 12% than the comparable area described by Henry (1972, 1975); wet forest was smaller by 8%. These differences were due to my inclusion of two additional small habitats described by Henry, shrub and herbaceous strand, into the five habitats, because I considered them too small for accurate separate analysis. Also the higher levels of Lake Erie may have added to wet woodland in 1972 when Henry conducted his study. The sizes of the areas were determined by planimetry on aerial photographs, and ground checks.

Within vegetative zones, each transect was located by subjectively finding a representative area and then randomly selecting a compass bearing for the transect. Each transect consisted of eight plots, 7.6×1.2 m, located consecutively along a stretched tape. Data collected for each plot included these: relative percentage cover of woody, herbaceous, and vine growth within 2 m of the ground; the ranked five most abundant species of woody, herbaceous, and vine growth; the percentage of stems of each species browsed (a "stem" was defined as single growth arising from the ground). The last named measure was simplified in analysis to whether or not a species was browsed in a plot, since browsing was always light (on only three plots exceeding 33% of stems).

The data were analyzed to determine availability and extent of utilization of browse species. Use of each species of woody vegetation was determined by adding the number of plots on which the species was browsed. Utilization so measured reflected relative amounts of various species eaten by deer to the extent that the location of transects reflected fairly the proportional availability of browse species. The proportion of transects in each habitat was carefully chosen to represent accurately the total deer habitat, as described.

Availability of browse species was determined by calculating prominence values for each species. This is an index of "commonness," obtained by multiplying the sum of densities of a species on all plots by the square root of its percent frequency of occurrence on plots. Density values for each plot were scored 5 for the most abundant species, 4, 3, 2, 1 for the others with decreasing degrees of abundance. Prominence values were used to describe availability of food species because they take into account both density and distribution and as such were viewed as more accurately reflecting availability to a wandering feeder such as deer than either measure by itself. Prominence values have been commonly used as a descriptive and analytical measure by botanists (Stringer and La Roi 1970; Douglas 1972), after first being applied to birds by Beals (1960).

The availability of herbaceous vegetation and vines was determined (Theberge. 1975. Summer assessment of aspects of the ecology of Whitetailed Deer in Point Pelee National Park. Unpublished report. Parks Canada, Cornwall, Ontario) but will not be described in detail here because utilization of those food items was determined only in general descriptive terms.

Results and Discussion

Eighteen (58%) of a total of 31 species (or in some cases genera) of woody plants (except vines) found on plots were browsed by deer (Table 1). Gooseberry (*Ribes* spp.) and hack-

TABLE 1—Availability and utilization of woody plants (non-vine) by White-tailed Deer at Point Pelee National Park, 1974

Species	Availability		Utilization, number (%) of plots
	Number of plots where found	Total prominence value[1]	
Hackberry (*Celtis occidentalis*)	90	2740	55(61)
Gooseberry (*Ribes* spp.)	74	2585	55(74)
Cherry (*Prunus* spp.)	73	2340	36(49)
Dogwood (*Cornus* spp.)	49	1542	18(37)
Raspberry (*Rubus* spp.)	37	807	16(43)
Staghorn sumac (*Rhus typhina*)	29	789	19(66)
Red cedar (*Juniperus virginiana*)	16	339	9(56)
Hop tree (*Ptelea trifoliata*)	12	214	6(50)
Sugar maple (*Acer saccharum*)	7	156	1(14)
Apple (*Pyrus malus*)	5	152	5(100)
White pine (*Pinus strobus*)	—[2]	134	
Fragrant sumac (*Rhus aromatica*)	7	117	5(71)
Rose (*Rosa* spp.)	5	115	2(40)
Silver maple (*Acer saccharinum*)	4	95	3(75)
Basswood (*Tilia americana*)	—	79	
Ash (*Fraxinus* spp.)	—	72	
Oak (*Quercus* spp.)	6	71	2(33)
Black walnut (*Juglans nigra*)	—	68	
Elderberry (*Sambucus pubens*)	5	64	1(20)
Hop hornbeam (*Ostrya virginiana*)	—	56	
Black locust (*Robinia pseudo-acacia*)	—	50	
Willow (*Salix* spp.)	—	49	
Tree of heaven (*Ailanthus altissima*)	—	48	
Slippery elm (*Ulmus rubra*)	—	36	
Mulberry (*Morus rubra*)	3	29	3
Buttonbush (*Cephalanthus occidentalis*)	—	18	
Ground juniper (*Juniperus communis*)	—	18	
Lilac (*Syringa* sp.)	1	18	1
Eastern cottonwood (*Populus deltoides*)	—	14	
Redbud (*Cercis canadensis*)	1	14	1
Sassafras (*Sassafras albidum*)	—	11	

[1]See text for method of calculating prominence values.
[2]Omitted, as not browsed.

berry were the most heavily used, on the basis of total number of plots browsed, followed by cherry (*Prunus* spp.), staghorn sumac (*Rhus typhina*), dogwood (*Cornus* spp.), raspberry (*Rubus* spp.), and red cedar.

The hackberry forest supported the most browsing by deer, totalling 133 (57%) tallies of plant species browsed on plots (Table 2). Wet forest, abandoned farmland, and red cedar forest ranked closely in that order, with cedar savanna supporting the least (Table 2). This order of browsing within habitats largely reflected differences in number of plots, which in turn reflected relative sizes of habitats (hackberry was the largest and was most browsed, while cedar savanna was the smallest and least browsed). Disproportionately heavy browsing also occurred, however, as determined by examining the total amount of browsing per plot in each habitat (dividing total browsing, shown in Table 2, by the number of plots, shown in the footnote to Table 2, for each habitat). Hackberry forest ranked highest in disproportionately heavy use (value of 1.1), followed by red cedar forest (1.08), and wet forest (0.9). The other habitats ranked much lower: abandoned farmland, 0.57, and cedar savanna, 0.31.

On examining the relative availability of woody plants, hackberry ranked first in prominence value, followed in order by gooseberry, cherry, dogwood, raspberry, and staghorn sumac (Table 1). Availability and utilization of browse species by deer correlated with a high level of confidence ($t = 0.01$) as determined by calculation of the correlation coefficient ($r = 0.97$). Only the species browsed by deer were

TABLE 2—Plots browsed by White-tailed Deer in various habitats at Point Pelee National Park, 1974

Species[1]	Habitat				
	Hackberry forest[2]	Red cedar forest	Cedar savanna	Abandoned farmland	Wet forest
Hackberry	38(69)[3]	2(4)		4(7)	11(20)
Gooseberry	42(76)	2(4)		3(6)	8(15)
Cherry	29(81)	1(3)		2(6)	4(11)
Staghorn sumac	2(11)	8(42)	1(5)	8(42)	
Dogwood	1(6)	4(22)	3(17)	2(11)	8(44)
Raspberry	8(50)	3(19)		4(25)	1(6)
Red cedar	2(22)	2(22)	1(11)	4(44)	
Hop tree	6(100)				
Fragrant sumac	1(20)	4(80)			
Apple				5(100)	
Silver maple					2(100)
Rose					2(100)
Oak	2(100)				
Sugar maple	1(100)				
Elderberry	1(100)				
Total (percent total browsing)	133(57)	26(11)	5(2)	32(14)	36(15)

[1]No species is listed that occurred on less than four plots.
[2]Total number of plots was 256, with 120 in hackberry forest, 24 in red cedar forest, 16 in cedar savanna, 56 in abandoned farmland, and 40 in wet forest.
[3]Number of plots where the plant species was browsed, followed in brackets by percentage of total plots in which the species occurred and was browsed.

used in this calculation.

Availability, measured by prominence value for stems of each species, does not take into account differences in life forms of various species, and hence cannot be considered completely accurate. Nevertheless, the correlation of availability with use indicates that deer were feeding on the most abundant woody species in the park.

Henry (1975) stated that "The hackberry and wet forest habitat types were also avoided because food plants were scarce and cover inadequate, especially in winter." My results are contradictory to those findings. Hackberry and wet forest habitats received the most plots browsed and browsing per plot. Henry observed deer relatively infrequently in those two habitats compared with the more open red cedar forest and abandoned farmland. His statement on lack of food plants was speculative and not backed up by an evaluation of browsing. His assertion of relatively low use of the two habitats is either valid in that it represented presence of deer but not necessarily feeding, or was biased by disproportionate probability in seeing deer in different habitats, a possibility he did not discuss, but from my experiences in the park, one that seems probable.

Some species were browsed commonly when found by deer (apple 100%, silver maple 75%, gooseberry 75%) (Table 1). Although this may indicate a significant impact of browsing on these species, such is not the case, since even on these plots, browsing did not exceed 15% of available stems of these species.

Observations were made of deer browsing on vines during this study. Wild potato vine (*Impomoea pandurata*) was seen being utilized in 30 observations. It is an uncommon vine, found only on 5% of plots. Wild grape (*Vitis riparia*) was seen being utilized 17 times. It, along with the less frequently used Virginia creeper (*Parthenocissus quinquefolia*) were the most common vines, found on 23 and 24% of plots respectively. In places, wild grape was abundant growing over red cedar and other low trees.

Feeding observations made between 15 January and 15 April 1975 showed that herbaceous plants were important as deer food. Twenty-four of 34 feeding observations were of grazing rather than browsing deer, and five of both grazing and

browsing. Grasses were used most often, then tall scouring rush (*Equisetum hyemale*). The former is common in the park (on 47% of plots established throughout the park as described under Methods), the latter is locally abundant in wet woodlands and marsh borders.

In summary, the results of this study show that, contrary to Henry's (1975) conclusions, which were based on distribution of deer in winter and not on vegetational analysis, there was no shortage of deer food in any habitats, and especially in hackberry and wet forests where most browsing occurred. Overutilization of the range was not occurring. Although Henry's statement is obviously ultimately true that "management of deer within the park would require the protection of habitat types affording both preferred forage and cover and sites with good cover and adjacent forage," food is not now limiting deer numbers. The vegetation could support more deer than at present. Supporting this statement are these facts: (1) browsing was spread over 18 species, (2) on only three plots did browsing exceed 33% of any species, (3) the seven most heavily used plant species were also the most common in the park, and one or another was a dominant species in each of the habitat types, (4) the whole range was available to deer in winter because of normally light or no snow cover, and (5) herbaceous vegetation supplements woody vegetation.

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Birds of the Coastal Zone of Melville Island, 1973–1975

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Observations of the birds along the coasts of Melville Island were obtained in the summers of 1973–1975. Thirty-eight species were recorded of which 21 were found breeding. Species recorded for the first time from Melville Island were Arctic Loon, Canada Goose, White-fronted Goose, White-winged Scoter, Least Sandpiper, and Semipalmated Sandpiper. New breeding records were obtained for Ruddy Turnstone, Semipalmated Sandpiper, and Arctic Tern. The lack of snow-free habitat in 1974 prevented most waterfowl and shorebirds from establishing nests. Birds that did successfully rear young nested on sandstone outcrops or on high ridges that became free of snow earlier than the low-lying areas.

Key Words: Northwest Territories, breeding birds, Melville Island, range extensions.

During 1973–1975, while employed in an integrated landscape survey involving the Geological Survey of Canada, the Forestry Management Institute, and the Canadian Wildlife Service, I studied migratory birds on eastern Melville Island in the Arctic Archipelago. The purpose of this paper is to report observations of birds seen in the coastal zone of Melville Island. No specimens were collected; however, the close approach generally possible in the Arctic, coupled with my previous experience with all of these species in northern Canada, allowed certain identification of even those birds found beyond their known ranges.

Localities Visited

During the summers 1973–1975, aerial surveys were flown along the coasts of Melville Island to determine distribution and numbers of birds (Figure 1). Our base camps were at Sherard Bay from 5 July to 28 August 1973, at Consett Head from 20 June to 11 August 1974, and at Sabine Bay from 25 June to 30 July 1975. G.R. Parker contributed the records for Bailey Point in June–August 1974. Locations where extensive ground coverage took place are shown in Figure 1.

The coastal zone of Melville Island, for the purposes of this paper, includes areas up to 8 km inland from the coast. It contains a variety of different habitats: tundra ponds, lakes, high-centered polygons, poorly-drained grassy meadows, poor-to-well-vegetated alluvial terraces, poor-to-well-vegetated discontinuous marine veneer (recent marine sediments, now above sea-level), beach ridges, braided streams, and coastal cliffs. Further information, classification and description of habitats may be found in the report by Barnett et al. (1975).

Results

Thirty-eight species of birds were found on Melville Island during the study. In 1973 and 1975 conditions were good. In 1974, spring was exceptionally late, and the snow cover was unusually deep owing to an above-average snowfall in the late winter and spring (D. C. Thomas, personal communication). When we arrived on 20 June 1974, there were no snow-free areas along the eastern coast of Melville Island. At Consett Head where we set up our main camp the only patch of open water was along the coast in the river valley.

Table 1 summarizes the species of birds seen on Melville Island in one or more of the three years and compares their presence and breeding status with those listed by Godfrey (1966) and Snyder (1957).

The following annotated list includes all species observed on Melville Island in 1973-1975.

ARCTIC LOON (*Gavia arctica*). Breeds on Banks and Victoria Islands. On 10 July 1973 four (1, 1, 2) in large bay along the southeastern coast near Beverly Inlet; first recorded for Melville Island. No evidence of breeding.

RED-THROATED LOON (*Gavia stellata*). Bred in 1973 and 1975 on tundra ponds and small shallow lakes; none bred in 1974.

FIGURE 1. The stippled strip represents routes of aerial surveys taken on Melville Island in 1973, 1974, 1975. Strips bordered by broken lines were surveyed only in 1973. The hatched areas show the locations covered by ground surveys in 1973–1975.

CANADA GOOSE (*Branta canadensis*). Breeds north to Victoria Island. One at Eldridge Bay on 6 July 1973, and 11 on 26 July 1975 at Weatherall Bay, mixed with flocks of non-breeding Brant; first records for Melville Island. All were from the middle-sized stocks *B.c. parvipes* or *taverneri*, rather than the small *minima* or *hutchinsii*.

BRANT (*Branta bernicla*). Bred in 1973, average brood size 3.4 (range 2 to 5), and 1975, average brood size 3.2 (range 1 to 7). Brood locations shown in Figure 2. All broods found in well vegetated areas. None bred in 1974. Previously treated as two species or subspecies, the light-bellied or Atlantic Brant regarded as *hrota* and the dark-bellied or Black Brant as *nigricans* (Delacour 1954). Both forms breed on Melville Island but the majority were intermediate in color.

WHITE-FRONTED GOOSE (*Anser albifrons*). Breeds from northern Yukon to northern Keewatin and southern edge of Victoria Island. One at Sabine Bay, 6 July 1975; first record for Melville Island.

SNOW GOOSE (*Anser caerulescens*). First record of breeding was in 1972 (Miller and Russell 1974). Bred in 1973, average brood size 4.3 (range 1 to 6) and 1975, average brood size 4.8 (range 3 to 7). Brood locations shown in Figure 2. In 1974, 1 pair at the Hubbard Lake System and small flocks of two to seven from 27 June to 6 July at Bailey Point; none known to have bred. Snow Geese handled at banding were *A. c. atlantica* (Greater Snow Goose). Melville Island is the most westerly part of known range of this form.

OLDSQUAW (*Clangula hyemalis*). Most were non-breeders; one brood on large lake at Little Point on 24 July 1973. None known to have bred in 1974 or 1975.

COMMON EIDER (*Somateria mollissima*). Breeds on Cornwallis, Devon, and southern Ellesmere Islands. One female in tundra ponds at Sabine Bay 2–5 July 1975; first confirmed record for Melville Island.

KING EIDER (*Somateria spectabilis*). Bred successfully in 1973 and 1975, primarily in small freshwater tundra ponds; breeding distribution shown in Figure 2. Only one nest found, at King Point, 11 July 1974, with eggs destroyed by jaegers.

WHITE-WINGED SCOTER (*Melanitta deglandi*). Breeds

TABLE 1—Species of birds seen on Melville Island, 1973–1975 compared to species recorded by Godfrey (1966) and Snyder (1957). X = recorded, B = nest or brood found

Species	Melville Island			Godfrey	Snyder
	1973	1974	1975	1966	1957
*Arctic Loon	X				
Red-throated Loon	B	X	B	B	
Fulmar *(Fulmarus glacialis)*					X
Whistling Swan *(Olor columbianus)*					X
*Canada Goose	X		X		
*White-fronted Goose			X		
Brant	B	X	B	B	X
Snow Goose	B	X	B	B?	X
Oldsquaw	B	X	X	B	X
Common Eider			X		X
King Eider	B	X	B	B	X
*White-winged Scoter		X			
Rough-legged Hawk	X	X		B	
Gyrfalcon	X			B	X
Peregrine Falcon	X				
Willow Ptarmigan				B	X
Rock Ptarmigan	B	X		B	X
Sandhill Crane		X			B
Ringed Plover *(Charadrius hiaticula)*					B
American Golden Plover		X	X	B	B
Black-bellied Plover	X	B	X	B	X
**Ruddy Turnstone		B	B		X
Red Knot	B	X	B	B	B
White-rumped Sandpiper	X	X	B	B	B
Baird's Sandpiper	B	X	X	B	B
*Least Sandpiper			X		
Dunlin		X			X
**Semipalmated Sandpiper	B	X	X		
Sanderling	B	B	X	B	B
Buff-breasted Sandpiper			X	B?	
Red Phalarope	B	B	B	B	B
Northern Phalarope *(Lobipes lobatus)*					X
Pomarine Jaeger	B	X	X	B	B
Parasitic Jaeger	X	X	X	B	B
Long-tailed Jaeger	B	B	B	B	B
Glaucous Gull	B	X	B	B	B
Thayer's Gull	X	X		B	
Ivory Gull *(Pagophila ebarnea)*					B
**Arctic Tern	B	B	B		X
Black Guillemot *(Cepphus grylle)*					X
Snowy Owl	X	X	X	B	B
Horned Lark		B		B	
Common Raven	X	X	X	B	X
Lapland Longspur	B	B	B	B	B
Snow Bunting	B	B	B	B	B
Number of species breeding	17	9	13	26	16
Number of species	28	30	28	27	34

* First sight records for Melville Island, Northwest Territories
**New breeding records for Melville Island, Northwest Territories

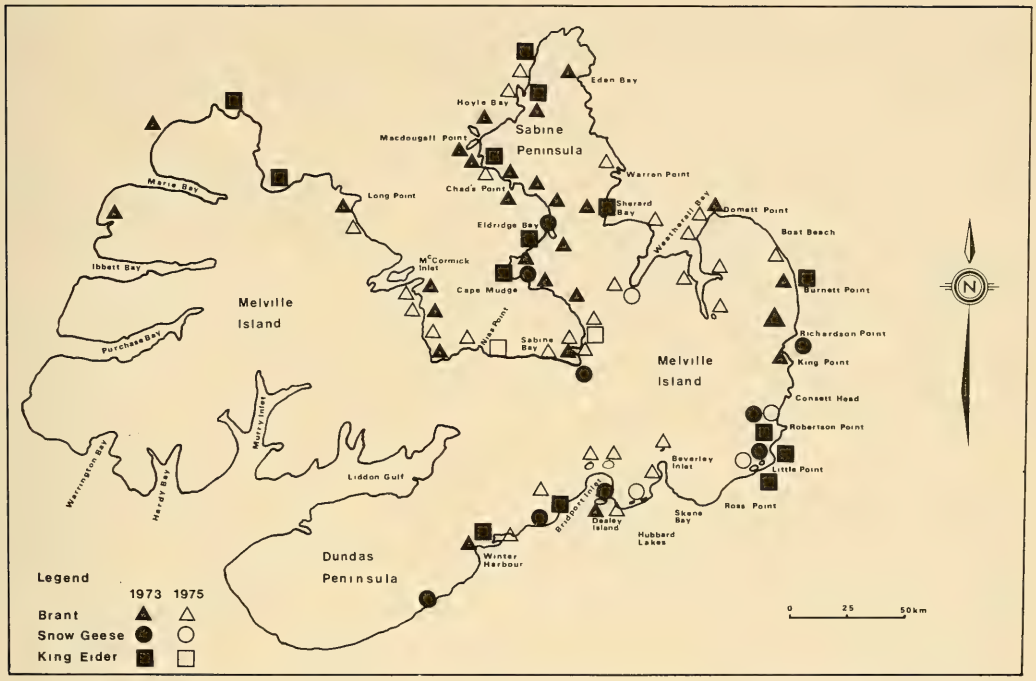

FIGURE 2. Locations of broods of Brant, Snow Geese, and King Eiders sighted on Melville Island in 1973 and 1975.

in Yukon and western Mackenzie, southern Keewatin and southward. One pair at Consett Head 12 July 1974; first record for Melville Island.

ROUGH-LEGGED HAWK (*Buteo lagopus*). One at Dundas Peninsula 10 July 1973; one at Bailey Point 26 June and 3 July 1974; both were dark-phase birds. None seen in 1975.

GYRFALCON (*Falco rusticolus*). One seen 6 km inland at Sherard Bay, 9 July 1973. No evidence of breeding.

PEREGRINE FALCON (*Falco peregrinus*). Suspected nesting around Winter Harbour and Dundas Peninsula in 1961 (Tener 1963). One near coastal cliffs and hills 800 ft elevation on Dundas Peninsula 10 July 1973. None seen in 1974 or 1975.

ROCK PTARMIGAN (*Lagopus mutus*). Bred in 1973. No young seen in 1974, and no ptarmigan seen in 1975. Both Willow Ptarmigan (*Lagopus lagopus*) and Rock Ptarmigan suspected to breed on Melville Island (Godfrey 1966); all seen and heard by us were Rock Ptarmigan.

SANDHILL CRANE (*Grus canadensis*). Suspected breeding at Winter Harbour (Snyder 1957). One from 26 June to 1 August 1974 at Bailey Point. None seen in 1973 or 1975. No evidence of breeding.

AMERICAN GOLDEN PLOVER (*Pluvialis dominica*). None seen in 1973. Two courting near Consett Head, 11 July 1974; two near tundra ponds, Sabine Bay, 25 June 1975. No nest or young found.

BLACK-BELLIED PLOVER (*Pluvialis squatarola*). One pair and one bird at Winter Harbour 8 July 1973, and one pair at Robertson Point 10 July 1973. One pair with nest and four eggs at Bailey Point 30 June to 25 July 1974; hatching on 25 July. Two at Sabine Bay 23 June 1975.

RUDDY TURNSTONE (*Arenaria interpres*). None seen in 1973. One adult with two fledged young at Bailey Point 10 July 1974, and on 4 July 1975 one adult with three young 4 km inland from Sabine Bay; first breeding records from Melville Island. Race on Melville Island not yet determined; *A.i. interpres* is found to north and east, and *A.i. morinella* to the south and west (Godfrey 1966).

RED KNOT (*Calidris canutus*). One nest with four eggs near tundra ponds at Sherard Bay on 11 July, and four broods (4, 4, 4, and 3 young) at Little Point, 12 July 1973. No nests or young found in 1974. Bred at Robertson Point in 1975. Race on Melville Island not yet determined; *C.c. canutus* breeds on Ellesmere Island; *C.c. rufa* breeds to south and east (Godfrey 1966).

WHITE-RUMPED SANDPIPER (*Calidris fuscicollis*). None found breeding in 1973 or 1974. Likely bred at Sabine Bay in 1975.

BAIRD'S SANDPIPER (*Calidris bairdii*). One brood (1 adult, 2 young) near lake at Little Point, 24 July 1973. None found breeding in 1974 or 1975.

LEAST SANDPIPER (*Calidris minutilla*). Breeds in Yukon, southern Keewatin, and east to Southampton Island; suspected breeding on southern Victoria Island. One pair at Sabine Bay 30 June 1975; first record for Melville Island. No nests or young found.

DUNLIN (*Calidris alpina*). Reported on southern Melville Island by Snyder (1957). Two separate birds near Little Point on 22 July 1974. None seen in 1973 or 1975.

SEMIPALMATED SANDPIPER (*Calidris pusilla*). Known to breed only as far north as Banks and Victoria Island. On 23 July 1973 one adult with four young at Little Point; first records of occurrence and breeding for Melville Island. A few seen in 1974 and 1975, but no breeding detected.

SANDERLING (*Calidris alba*). Two adults with four young at Little Point 24 July 1973 and one adult with two newly fledged young at Bailey Point on 7 August 1974. Many seen in 1975 but none found breeding.

BUFF-BREASTED SANDPIPER (*Tryngites subruficollis*). None seen in 1973 or 1974. Four displaying near tundra ponds at Sabine Bay on 23 July 1975. No evidence of breeding.

RED PHALAROPE (*Phalaropus fulicarius*). Two broods in tundra ponds at Sherard Bay 19 July (two adults with two young) and 21 July (one male with one young) in 1973. Bred at Bailey Point in 1974; a male with a nest with four eggs found on 12 July 1974. Bred in 1975 at Sabine Bay in area containing many tundra ponds.

POMARINE JAEGER (*Stercorarius pomarinus*). Nest found 11 July 1973 near tundra ponds, and on 14 July, two adults and two young on alluvial terraces at Sherard Bay. Four seen in 1974. Only one observed in 1975. Both light and dark phases present.

PARASITIC JAEGER (*Stercorarius parasiticus*). Nine singles seen on beach ridges near Weatherall Bay 10 July 1973, and one near tundra ponds at Sabine Bay in 1975. None seen in 1974. Not likely breeding. All light phase.

LONG-TAILED JAEGER (*Stercorarius longicaudus*). Common: bred in all 3 years on Melville Island. Four broods (ranging from 1 to 2), and two nests both with three eggs seen in 1973; three-egged clutches are unusual for this species (D.J.T. Hussell, personal communication) and have not been found elsewhere in the Arctic.

GLAUCOUS GULL (*Larus hyperboreus*). Common on Melville Island. In 1973 and 1975 most nests found in small colonies on stacks along coastal cliffs of Dundas Peninsula and Weatherall Bay. None bred in 1974.

THAYER'S GULL (*Larus thayeri*). Only three identified in 1973, one in 1974, and none in 1975; all along the coast between Burnett Point and Ross Point. None found breeding.

ARCTIC TERN (*Sterna paradisaea*). A colony of 75 on Dealy Island 10 July 1973 and a large colony of undetermined nesting status on a small island east of Cape Bounty, as well as several pairs breeding at the mouths of rivers, were first breeding records for Melville Island. Bred in 1974 at Consett Head and Bailey Point, but not at Dealy Island which was snow-covered. A colony of 250 terns bred at Dealy Island in 1975.

SNOWY OWL (*Nyctea scandiaca*). Many owls seen but no nests or young found in 1973–1975.

HORNED LARK (*Eremophila alpestris*). On 25 June 1974 three feeding 6 km inland from coast at Consett Head and 7 July four seen near Rae Point. Nest with six eggs found 6 July 1974 at Bailey Point. None seen in 1973 or 1975.

COMMON RAVEN (*Corvus corax*). A total of 21 seen; many attracted to garbage dumps around camps. No young or nests found.

LAPLAND LONGSPUR (*Calcarius lapponicus*). Bred in all 3 years. Seen mainly around lakes and tundra ponds on beach rides.

SNOW BUNTING (*Plectrophenax nivalis*). Bred all 3 years. Most clutches consisted of four eggs or young. Little affected by adverse weather conditions in 1974.

Discussion

Many avifaunal lists have been compiled for Canada's Arctic islands, but most have been based on a single season's work. Longer-term studies have been mostly on the breeding biology of a single species, and particularly of Arctic-nesting geese. The fact that such Arctic geese experienced years in which no reproduction at all took place has been known for at least two

decades, and 1974 was only the latest example of such years. This study, however, is perhaps the first to show the extent to which such adverse seasons affected reproduction of birds other than geese; moreover, it provides data for two other, more or less normal seasons for comparison.

In 1974, the lack of snow-free habitat prevented most waterfowl and shorebirds from establishing nests. Of the five species of waterfowl and loons seen in all three years, all bred in 1973, none in 1974, and four were known to have done so in 1975. The pattern is less clear for shorebirds, probably because breeding evidence was harder to obtain; five, four, and four species, respectively, of shorebirds bred in the three years. For jaegers, gulls, and terns, the yearly totals breeding were four, two, and three, and the two ubiquitous passerines bred each year. The species that were able to breed successfully in 1974 were those that nested in snow-free situations such as ridges, outcrops, river-mouth flats, but a few individuals of other species bred in locally snow-free areas like Bailey Point.

This paper lists five species not previously reported for Melville Island, of which one — with two other species — represents new breeding records for the island. This study obtained records of five species, which were listed for Melville Island by Snyder (1957) but which were not accepted by Godfrey (1966). It seems possible that further field work would substantiate some of the six other species shown by Snyder but as yet unconfirmed.

Acknowledgments

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Above-ground Biomass of Vascular Plants in a Subarctic James Bay Salt Marsh

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Vegetation studies including determination of species composition and cover were made along a transect in a subarctic salt marsh located on the southwestern coast of James Bay, Ontario, Canada. Eight vegetation zones were recognized from an intertidal colonization area dominated by *Puccinellia phryganodes* to the edge of a willow thicket at the landward end of the marsh complex. In each zone, above-ground biomass of vascular plants was determined by clipping at the time of peak biomass. Values ranged from an estimated low of 29 g/m^2 dry weight on gravel beach ridges and 157 g/m^2 in the mid-marsh to a high of 569 g/m^2 in the zone nearest the willow thicket, which was dominated by *Juncus balticus*. A weighted-mean above-ground biomass for the transect was 357 g/m^2, taking into account the biomass and the width of these zones. The biomass values found in this study were lower than reported in the literature for salt marshes located on the Atlantic coast of North America between Georgia and Nova Scotia but were higher than those reported for Swedish salt marshes located on the Baltic Sea.

Key Words: salt marsh, James Bay, vegetation, above-ground biomass, subarctic, Ontario.

The western coast of James and Hudson Bays south of Churchill, Manitoba, is characterized by extensive salt-marsh development. Physiographically, the coastal area consists of long stretches of relatively straight shorelines which are fairly flat in relief, averaging 0.6 m/km in terms of slope. This flat topography allows high spring and fall tides to extend inland for as much as several kilometres in some areas especially when such tides are accompanied by high winds off the bay. Coastal features such as beach ridges formed by isostatic uplift (Moir 1954) act to trap sediments, thus stabilizing the substrate for vegetative growth. Such features also restrict the flow of tidal waters inland, thus controlling the width of salt marshes. Also, usually the salt marsh grades into a freshwater marsh/fen complex.

Little work has been done on the vegetation ecology of such salt marshes. Previous studies have dealt mainly with floristic aspects (Dutilly et al. 1954; Porsild 1957; Schofield 1959). The only ecologically-oriented study of salt marshes in the area was done by Kershaw (1976) who studied vegetational zonation in salt marshes at East Pen Island on Hudson Bay, which is located just south of the Manitoba–Ontario border. Owing to the lack of ecological studies in these salt marshes, a study was begun of vegetational composition and structure at North Point, Ontario, on James Bay (51°29′N, 80°27′W), which is located approximately 27 km NE of Moosonee, Ontario (Figure 1).

This area was chosen because it is the site of a Canadian Wildlife Service shorebird migration research project; the coast is a very important waterfowl flyway. Climatic data are not available at North Point, but data available for nearby Moosonee indicate that area has a growing season (period when mean daily temperatures are above 5.6° C) of approximately 143 days starting in mid-May and running through the first week of October. Temperatures of below 0° C, however, can occur until 19 June and after 27 August on the average. Winter temperatures average –21 to –23° C, and an all-time low of –47° was recorded in Moosonee. Summers are warm with an average July temperature of 16° C. Yearly precipitation is 76 cm, of which approximately one third occurs as snow (Chapman and Thomas 1968; Thompson 1968). This precipitation is divided fairly evenly over the year. The area is classified climatologically as subarctic and the dominant upland vegetation is typically northern boreal forest with large inland areas of bog and fen vegetation (Hustich 1957).

The purpose of this paper is to report on the above-ground biomass of plants with emphasis on estimates for recognized salt-marsh zones in

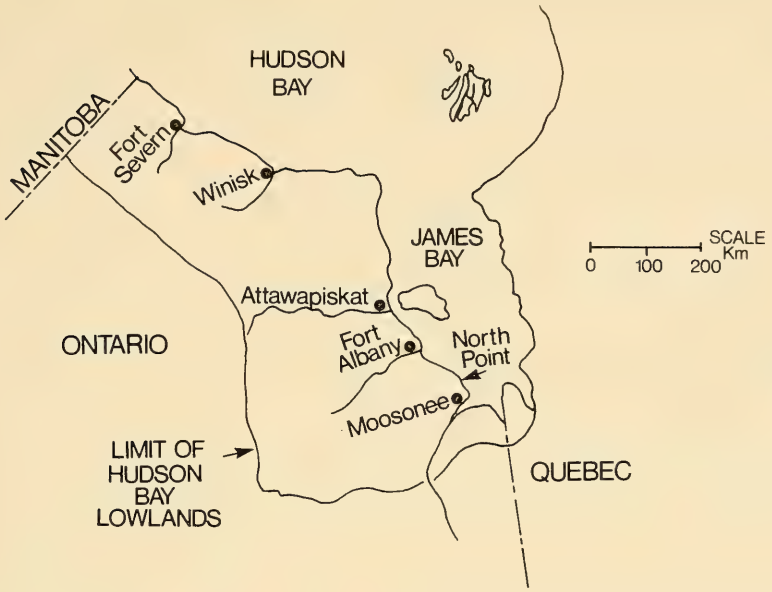

FIGURE 1. Map of Hudson Bay Lowlands showing North Point, site of salt marsh study.

the North Point study area. A detailed analysis of the vegetation structure of the North Point salt marshes is in progress.

Methods

Three transects perpendicular to the shore were set up by surveying with a transit and stadia rod. This was done before the beginning of vegetative growth in mid-May 1976. These transects were approximately 1 km in length and ran from the intertidal zone seaward of plant colonization to the edge of a well defined willow-thicket vegetation zone located on an old beach ridge that marked the termination of the salt-marsh complex at North Point. A profile of this is shown in Figure 2. Owing to an absence of bench marks in the area all elevations are relative. Vegetation analysis was done on the transects during 11–13 August 1976 coinciding with the time of apparent peak biomass. Other salt marsh studies have indicated that peak above-ground biomass in salt marshes occurs from late July to mid-August (Tyler 1971; Keefe and Boynton 1973; Wallentinus 1973; Hatcher and Mann 1975). At 10-m intervals a quadrat (1×1 m), was placed on the transect and all species of plants were recorded with an estimation of percent cover using Braun-Blanquet's scale (Poore 1955). Sources of plant species names were Gleason and Cronquist (1963) and Porsild (1973). From the results, eight fairly distinct zones of vegetation were present from the lower intertidal zone to the edge of the willow thickets. As a result of a lack of time only one transect was chosen for above-ground biomass studies. In each zone, up to five random tosses of a 0.125-m^2 rectangular quadrat (25×50 cm) were made and on each site all above-ground vegetation including attached dead plant parts was clipped with lawn shears. Last year's carry-over of dead plant litter was excluded. On the gravel beach ridges, vegetative cover was estimated to be 5% of the total area. To estimate biomass here, sites of 100% vegetation cover were clipped, dry weights determined, and the average dry weight multiplied by 5% to get a rough cover estimate for the gravel ridge zone. The plant material thus obtained was placed in a paper bag and allowed to air-dry until return to the laboratory. There, samples were oven-dried for 48 h at 80°C, allowed to cool to room temperature, and the dried vegetation was weighed to the nearest 0.1 g. From this, weights were converted to a grams dry-weight per square

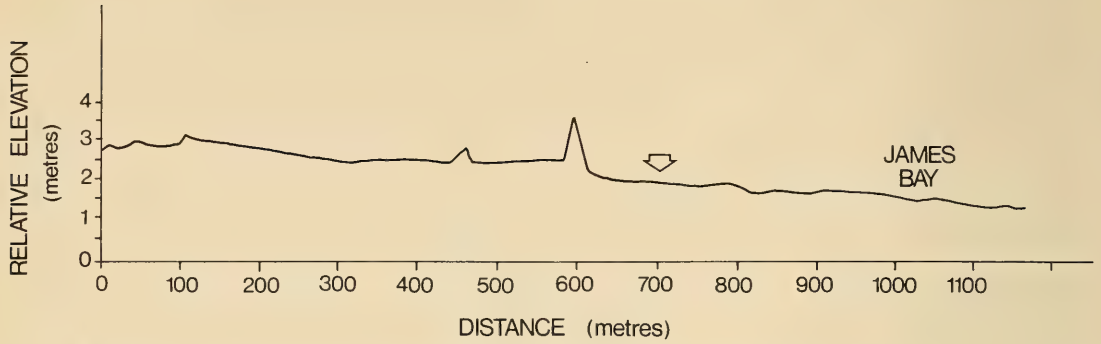

FIGURE 2. Profile of transect with relative elevation in metres. Arrow depicts mean high-tide line as evidenced by accumulation of dead benthic algae such as *Fucus* spp. and dead *Zostera marina*.

metre basis. This is the same definition of above-ground biomass as used by Tyler (1971), Wallentinus (1973), and Hatcher and Mann (1975).

Results

Topographically the only significant relief occurring in the area of the transect occurs in the form of two beach ridges (Figure 2). The most seaward of these ridges has a height of 1.6 m on its foreshore face, a base width of 25 m, and a backshore height of 1.0 m. The ridge is made up of angular pebbles formed by freezing and thawing processes. The second smaller ridge was located 140 m landward of the main ridge, was 9 m in width and 0.25 m higher than the surrounding land surface. Seaward of the main ridge, the transect was extended 340 m to the outermost beginning of colonization of the intertidal area by vegetation, in this case sparse *Puccinellia phryganodes*. There are some sites seaward of this point, however, where *Zostera marina* was observed to occur. The difference of elevation over this distance was only 0.4 m (1.2 m/km). The inter-ridge area was flat, and landward of the second ridge, a gradual slope of 0.4 m over a 290-m distance was noted (1.4 m/km). Thus the area is very flat, and during a high-tide period in late August 1976, water came inland approximately 450 m beyond the main ridge. Previous to that, the highest tides came only as far as the seaward face of the main ridge. Thus the ridges tend to act as a barrier to the landward movement of tidal waters and are therefore an important ecological feature in controlling the extent of salt-tolerant plant species.

Vegetation data from the clipping quadrats including above-ground biomass, species composition, percent cover, and width of vegetative zone, are presented in Table 1. The most seaward zone is the lower intertidal zone in which colonization by vascular plants occurs, mainly *Puccinellia phryganodes*. This area is characterized by a turf-like appearance with fairly complete vegetative cover with the exception of very shallow pond-like depressions, which appear to be caused by scouring by ice action. No ponds were located in the clipping quadrats, but they often contain *Ruppia maritima*. *Scirpus maritimus* occurs on the pond edges, along with *Triglochin maritima* and very sparse *Suaeda maritima*. As one gets higher up the profile towards the beach ridges into the upper intertidal zone (Zone 2), development of small depressions, characterized by high-salt content due to evaporation, known as pannes, occur. Here *Plantago maritima* becomes quite abundant along with *Atriplex glabriuscula, Glaux maritima, Salicornia europaea, Triglochin maritima,* and some *Potentilla egedii* even though these did not necessarily occur in the quadrats that were clipped.

Both ridges are included in Zone 3 and are characterized by very sparse vegetation, mainly *Elymus mollis* in large clumps with some rosettes of *Honkenya peploides* and *Mertensia maritima*. A rough estimate of above-ground biomass on these ridges would be approximately 29 g/m^2 by the method previously described.

The area between the ridges (Zone 4) is fairly productive and characterized by the species *Potentilla egedii* and *Hordeum jubatum*. Some

TABLE 1—Above-ground biomass data for North Point Salt marsh zones. For cover estimate, + = 1%, 1 = 1–5%, 2 = 5–25%, 3 = 25–50%, 4 = 50–75%, 5 = > 75%

Zone	Above-ground biomass, $g \cdot m^{-2}$ dry wt	Width of zone, m	Vegetation with Braun-Blanquet cover estimate
(1) Intertidal colonization	373.6		*Puccinellia phryganodes* (5)
	515.2		*Puccinellia lucida* (3), *P. phryganodes* (3)
	288.0	160	*P. phryganodes* (5)
	360.8		*P. phryganodes* (5), *Glaux maritima* (2)
	421.6		*P. phryganodes* (5), *Scirpus maritimus* (2)
	Mean 391.8		
	SD 83.9		
(2) Upper intertidal	270.4		*Plantago maritima* (5), *Puccinellia phryganodes* (3)
	326.4		*Puccinellia phryganodes* (5), *Plantago maritima* (3), *Salicornia europea* (+)
	289.6	180	*Plantago maritima* (4), *Puccinellia phryganodes* (3), *Atriplex glabriuscula* (4), *Salicornia europaea* (4)
	349.6		*G. maritima* (4), *Plantago maritima* (2)
	Mean 309.0		
	SD 35.7		
(3) Ridges		30	*Note:* Assuming 5% total vegetative cover of beach ridges, biomass estimated to be 29 g/m^2. This is based upon clipping three clumps of *Elymus mollis* (100% cover), getting values of 504.0, 616.0, and 600.8 g/m^2, average = 573.6 g/m^2 and multiplying by 5%
(4) Interridge	381.6		*Potentilla egedii* (5), *Hordeum jubatum* (+), *Atriplex patula* (+)
	332.8		*Potentilla egedii* (5), *H. jubatum* (2), *A. patula* (+), *Salicornia europaea* (+)
	460.0	50	*Potentilla egedii* (4), *H. jubatum* (2), *A. patula* (+)
	314.4		*Puccinellia lucida* (3), *Plantago maritima* (2), *H. jubatum* (1), *Potentilla egedii* (1), *Salicornia europaea* (+)
	263.2		*Plantago maritima* (3), *A. patula* (2), *H. jubatum* (1), *Potentilla egedii* (1), *Puccinellia lucida* (1)
	228.0		*Potentilla egedii* (4), *Puccinellia lucida* (3), *H. jubatum* (2)
	Mean 330.0		
	SD 83.3		
(5) *Triglochin-*	136.0		*A. patula* (3), *H. jubatum* (2), *Potentilla egedii* (1), *Puccinellia lucida* (+)
Potentilla	188.0		*Triglochin maritima* (4), *Potentilla egedii* (3), *Aster novi-belgii* (+)
	144.0	160	*Potentilla egedii* (4), *T. maritima* (2), *Plantago maritima* (1)
	206.4		*T. maritima* (3), *Potentilla egedii* (2), *Plantago maritima* (1), *A. patula* (+), *Puccinellia lucida* (+), *Salicornia europea* (+)
	117.6		*Plantago lucida* (2), *T. maritima* (2), *H. jubatum* (4), *A. patula* (4)
	Mean 158.6		
	SD 37.4		
(6) *Carex*	313.6		*Carex paleacea* (4), *Potentilla egedii* (1), *G. maritima* (4), *T. maritima* (4)
paleacea	526.4		*C. paleacea* (5), *T. maritima* (4)
	467.2		*C. paleacea* (5), *T. maritima* (1), *Potentilla egedii* (4)
	401.6	170	*C. paleacea* (2), *T. maritima* (2), *Potentilla egedii* (1), *G. maritima* (4)
	Mean 431.4		
	SD 79.6		

Continued on next page

TABLE 1 *continued*

Zone	Above-ground biomass, $g \cdot m^{-2}$ dry wt	Width of zone, m	Vegetation with Braun-Blanquet cover estimate
(7) *Scirpus* ponds	188.8		*S. maritimus* (2), *T. maritima* (4)
	185.6		*S. maritimus* (2)
	308.8	40	*S. maritimus* (3)
	Mean 227.7		
	SD 70.2		
Juncus	539.2		*Cicuta maculata* (2), *Aster novi-belgii* (2), *Juncus balticus* (2), *Potentilla egedii* (2), *Galium labradoricum* (+), *Poa* spp. (+)
	495.2		*C. maculata* (2), *Parnassia palustris* (2), *Rhinanthus Crista-galli* (2), *J. balticus* (2), *T. maritima* (+), *Poa* spp (+)
	703.2	90	*J. balticus* (5), *Potentilla egedii* (2), *T. maritima* (1), *C. maculata* (1), *Lathyrus palustris* (1), *C. maculata* (2), *C. paleacea* (2), *Potentilla egedii* (2), *T. maritima* (2), *Ranunculus cymbalaria* (+), *Eleocharis palustris* (+)
	599.2		*Aster novi-belgii* (3), *J. balticus* (2), *Potentilla egedii* (2), *G. labradoricum* (+)
	Mean 569.0		
	SD 85.1		

sites within this inter-ridge zone are occupied by *Atriplex patula* and *Salicornia europaea*, especially where salinities of the soil appear to be elevated, as indicated by the presence of salt crusts on the surface. Landward of the ridges was the least productive area, Zone 5, characterized by sparser distribution of vegetation, mainly *Triglochin maritima* and *Potentilla egedii*. This zone was fairly dry during most of summer until the high tides of late August inundated it. Also, salt crusts occurred in some parts of the zone; hence it may be lower in productivity because of its arid nature and possibly increased soil salinity. This hypothesis is the subject of further investigation. Figure 3 illustrates this zone.

Landward of this zone are two wetter environments, a clearly defined zone of *Carex paleacea* (Zone 6) and a series of ponds dominated by *Scirpus maritimus* (Zone 7). The *Scirpus* ponds did not have a very high above-ground biomass, 228 g/ m^2, but they were rich in benthic algae and often contained the aquatic macrophytes *Hippurus vulgaris* and *Zannichellia palustris*. This algal community was not sampled; hence, the *Scirpus* biomass is an underestimate for the zone.

The last zone (8) was dominated visually by *Juncus balticus* and *Cicuta maculata*. This zone had some wet depressions in which *Potentilla egedii* and *Triglochin maritima* were found. In general, however, the zone was characterized by terrestrial species. The zone ended in a willow thicket dominated by *Salix bebbiana* and *S. candida*; however, the beginning of the willow thickets was not a sharp transition but was characterized by scattered willows. The willow thicket was located on an old beach ridge with weak soil development. In some areas of the willow thicket, freshwater marshes occurred, characterized by such species as *Typha latifolia, Carex rostrata, C. aquatilis, Petasites sagittatus, Equisetum fluviatile* and others. The willow thicket and freshwater marshes gave way to treed fen including *Picea mariana, Picea glauca, Populus balsamifera,* and *Larix laricina*. Some graminoid fen areas also were present, but in the present study only the salt marsh vegetation was considered, and biomass measurements were stopped at the thicket.

Discussion

Two points merit discussion, namely the distribution of biomass in the marsh, and a comparison of the North Point salt marsh with other published biomass data for salt marshes. The highest biomass, 569 g/ m^2, occurred in the uppermost zone studied (Zone 8), which was

FIGURE 3. Photograph of Zone 5. Area in foreground is documented by *Plantago maritima* while *Triglochin maritima* and *Potentilla egedii* are adjacent to it. Boreal forest is in background.

dominated by *Juncus balticus, Cicuta maculata,* and other more terrestrial species. A possible explanation for this higher biomass is that vegetative growth begins relatively early in this zone as observed in May by the presence of unidentifiable green shoots up to 5 cm in height. During the third week of May 1976, vegetation was already growing in this zone and on the beach ridges (Zone 3), while in Zones 4–7, the ground was still frozen several centimetres below the surface and only a few vegetative shoots or rosettes had started to appear above ground, mainly *Puccinellia lucida.* The intertidal area, Zones 1 and 2, was still covered by ice for the most part. In mid-May 1977, ice was not present in Zone 1 and *Puccinellia phyrganodes* had started to grow, with blades up to 2 cm in length. Thus, it appears that Zone 8 may be characterized by a longer growing season.

Next to Zone 8, the *Carex paleacea* zone (Zone 6) had highest above-ground biomass closely followed by Zone 1 (lower intertidal). The lowest biomass values were obtained in the xeric beach ridges; next lowest is Zone 5 which tends to be xeric and possibly higher in salt content, based upon visual observations. Thus it appears that important factors determining the distribution of productivity at North Point include length of growing season as influenced by soil and sediment temperature, soil moisture regime, and salinity.

Comparing North Point data with other available data for salt marsh above-ground biomass, Table 2 was compiled using only more northerly salt-marsh data. A weighted mean above-ground biomass was calculated using width of zones and biomass of each zone for North Point excluding the beach ridges. This weighted mean was 357 g/m^2 with a range of 29–599 g/m^2. This appears somewhat lower than values found in North American Atlantic coast salt marshes, but is higher than that determined for two Swedish Baltic Sea salt marshes. None of the authors previously cited used this weighted-mean calculation, but simply used either a range of biomass values or an average (see Table 2). I feel, however, that such weighting techniques give a better idea of above-ground biomass in the salt-marsh complex. Of course, zone widths can vary. A simple mean, neglecting zone widths, is 344 g/m^2 which is very close to the weighted-mean. Thus values determined in this study appear reasonable. Even though James Bay is subarctic in nature, the

TABLE 2—Above-ground biomass data for selected salt marshes

Author	Geographic locality	Vegetation	Above-ground biomass (dry wt· $g \cdot m^{-2}$)
Keefe and Boynton (1973)	Chincoteague Bay, Maryland-Virginia, USA	*Spartina alterniflora*, *Distichlis spicata*	427–558
Udell et al. (1969)	Long Island, N.Y., USA	*Spartina alterniflora*, *Spartina patens*, *Distichlis spicata*	508–827 503 648 (average value for several sites of each species)
Hatcher and Mann (1975)	Nova Scotia, Canada	*Spartina alterniflora*	448–762 (average = 558)
Wallentinus (1973)	Baltic Sea, S. Sweden	*Juncus gerardi*, *Agrostis stolonifera*, *Plantago maritima*, *Festuca rubra*, *Triglochin maritima*, *Glaux maritima*	324
Tyler (1971)	Baltic Sea, S. Sweden	*Juncus gerardi*, *Eleocharis uniglomis*, *Agrostis stolonifera*, *Triglochin maritima*, *Glaux maritima*, *Plantago maritima*	161
Glooschenko (this study)	North Point, Ontario James Bay	See Table 1	228–569. Mean is 344 with a weighted mean based upon zone width of 357

values determined are not a great deal lower than for more southerly coastal marshes in Nova Scotia and U.S. Atlantic coast states.

As an indication of net primary production rates in the salt marsh the works of Tyler (1971) and Wallentinus (1973) in Baltic Sea salt marshes are of interest, where values of 230 and 430 $g \cdot m^{-2} \cdot yr^{-1}$, respectively, were found. The ratio of these net production values to biomass are 1.43 and 1.33. If we use 1.4 as an approximate ratio of net production to biomass the North Point ranges of net primary production excluding the beach ridge would be 222–797 $g \cdot m^{-2} \cdot yr^{-1}$ having a mean of about 500 $g \cdot m^{-2} \cdot yr^{-1}$. This would place the North Point salt marshes ahead in productivity of such ecosystems as lakes and streams and most oceanic and tundra ecosystems, but below temperate grasslands in productivity (Whittaker 1975; Coupland 1975). Such salt marshes would, however, be somewhat less productive than boreal forests. These salt marshes would also exceed the productivity of most arctic ecosystems (Wein and Rencz 1976; Wielgolaski 1975). Future studies in the area will emphasize above-ground productivity measurements in relation to soil chemistry.

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Food Habits of Three Sympatric Species of Insectivora in Western Washington

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Terry, Carol J. 1978. Food habits of three sympatric species of Insectivora in western Washington. Canadian Field-Naturalist 92(1): 38–44.

Sorex vagrans vagrans, S. trowbridgii trowbridgii, and *Neurotrichus gibbsi minor* were maintained in captivity and fed seeds of various herb, shrub, and tree species. Invertebrates, carrion, and mushrooms were also provided. The only seed species rejected by all individuals tested was purple foxglove (*Digitalis purpurea*). *Neurotrichus,* the largest of the species studied, readily consumed all other food items offered. *Sorex vagrans* and *S. trowbridgii* were restricted to smaller food items, seemingly because of their inability to penetrate heavy seed coats and capsules, and thick exoskeletons.

Key Words: *Sorex, Neurotrichus,* shrews, competition, sympatry, granivory.

Several species of shrew (*Sorex*) and the shrew mole (*Neurotrichus*) are often collected in the same habitats in western Washington. Because these species are small, have high metabolic rates (Pearson 1948), and require large amounts of food to survive (Broadbooks 1939; Morrison et al. 1957; Buckner 1964), it seems likely that food may at times be limiting, resulting in interspecific competition. To examine potential competition for food among these species, I studied the food and feeding habits of sympatric *Sorex trowbridgii trowbridgii, S. vagrans vagrans,* and *Neurotrichus gibbsi minor.* Mean weight and standard error for the three species were respectively 5.1 ± 0.22 g (n = 16), 4.2 ± 0.19 g (n = 18), 7.8 ± 0.45 g (n = 4). This investigation focused on the types of foods eaten and the size of food items. Due to the small body size of the animals, size of acceptable food items may be an important factor in influencing their diet and the intensity of interspecific competition. Although shrews are considered to be primarily insectivorous (Jameson 1955; Williams 1955; Findley 1967) they also consume seeds (Ingles 1967; Criddle 1973) and may be major predators on seeds of Douglas fir (*Pseudotsuga menziesii*) and other conifers (Moore 1942; Gashwiler 1970). Since herb, shrub, and tree seeds are potentially numerous in western coniferous forests, it would seem advantageous for an animal with so high a metabolic rate to take advantage of this energy source.

Most food studies of *Sorex* consist of examination of stomach contents (Whitaker and Mumford 1972; Rudge 1968). I have observed that captive shrews often remove the seed coat before ingesting the endosperm; thus stomach contents examination may not detect the presence of seeds, and previous studies may have underestimated the role of seeds in the diet of shrews. Moreover, examination of stomach contents gives only an indication of what the shrews had eaten very recently and what was immediately available to them. It is biased in favor of those foods that are less readily digestible and those that are seasonally available. Therefore to obtain an indication of acceptable sizes and types of food items, I observed the feeding habits of several shrews and shrew moles in captivity.

Methods

In July 1972 five *Sorex trowbridgii trowbridgii,* five *S. vagrans vagrans,* and two *Neurotrichus gibbsi minor* were captured live in buried half-gallon paint cans in a seral Douglas fir (*Pseudotsuga menziesii*) stand 32 km east of Issaquah, King County, Washington. Each animal was transferred to a 76-L aquarium containing 5 to 10 cm of humus, the surface of which was half covered with moss

(*Eurhynchium oreganum*). The aquaria were kept indoors in an area not subject to any regular human or mechanical disturbance. Animals were maintained on a diet of millet and Tyrell's chicken dog food; during the first few days of captivity they were offered various insects and tree seeds in addition.

Tree seeds for experimentation and accurate information on viability of seed lots were made available by the Washington State Department of Natural Resources. Herb and shrub seeds were gathered from the area in which the animals had been collected. I conducted three types of tree seed tests: encounter/preference tests, hourly tests, and 12-h tests. Seeds were offered on aluminium pans, 10 × 15 cm, which had been taped to reduce vibrations and which the shrews had used previously as food containers. All food was removed from the cages at least one hour prior to the initiation of the encounter/preference and hourly tests.

Encounter/Preference

The encounter/preference test was designed to determine any immediate preference for different species of seeds. Animals were presented with equal amounts of evenly spaced seeds: either four seeds of two species were alternated in a straight line or 10 seeds of two species were alternated in a 4-by-5 grid. No specific time interval was set because of variability of activity patterns; instead, tests were terminated when there was a pause in the animal's activity and at least half of the seeds had been removed or eaten.

Hourly Tests

Both species of shrews exhibited hoarding behavior during early captivity, carrying seeds some distance from the seed pan and burying them in the moss or soil. Because of this, it was not possible to give the shrews large numbers of seeds and correlate the number removed or eaten with consumption or activity, for the shrews might remove large quantities of seeds when they were first presented and then eat them over an extended period of time. A partial solution to this problem was to give the shrews a small number of seeds over short periods of time. Therefore, for the hourly tests, 20 seeds of each of the two or three tree species being compared were given to the animals at hourly intervals. Tests lasted from 10 to 17 h and were conducted at different times during the day and night. In this way possible variations in consumption and activity rates during different periods of the day, and associated changes in preferences, could be detected. Supplemental food was not available to the animals during the hourly tests.

Viability of individual seeds was unknown, so during the hourly tests uneaten seeds were replaced by seeds of the same species in order to reduce any error as a result of unacceptable seeds. If more than five seeds (25%) of any one species was removed by the animals during the hour, the remaining seeds of that species were discarded and 20 new seeds were given. If less than 25% of any one seed species had been removed, the number of seeds removed by the animal was replaced with new seeds. Therefore at the beginning of every hour 20 seeds of each tree species were available to each animal.

12-h Tests

The third type of seed test involved giving the animals a specific number of seeds of various tree species for 12-h intervals. This test eliminated any disturbance factor owing to changing seeds at hourly intervals and provided information on degree of preference: i.e., whether a certain seed species was eaten in smaller amounts during the hourly tests only because a more preferred species was present, but would be eaten readily if it were the only seed available. In order to reduce the risk of losing shrews through starvation or lack of some particular nutrient (Crowcroft 1951), measured amounts of dog food were present during these 12-h tests.

No quantitative tests were made for herb and shrub seeds and fruits because only small amounts were available, and seed viability was uncertain. Fruits and seeds were offered at random, and the animals' behavior toward the item was recorded. For larger seeds (*Lilium columbianum* and *Lupinus latifolius*) lots of four or five were offered, while for the smaller seeds (*Digitalis purpurea* and *Lamium purpureum*) at least 20 were presented at one time. Dog food was always present during the herb and shrub seed tests.

Insects, slugs, carrion, and mushrooms, as they became available, were also offered at random to the shrews. Dog food was not present

TABLE 1—Seeds removed during encounter/preference tests

Tree species pairs compared	Species tested	Number of replicates	Seeds removed, %
Abies procera, *Pinus monticola*	*Sorex vagrans*	2	14 50
Pseudotsuga menziesii, *Pinus monticola*	*Sorex vagrans*	2	60 90
Abies procera, *Pinus monticola*	*Sorex trowbridgii*	3	83 100
Pseudotsuga menziesii, *Pinus monticola*	*Sorex trowbridgii*	5	76 80
Abies procera, *Pinus monticola*	*Neurotrichus gibbsi*	2	38 88
Pseudotsuga menziesii, *Pinus monticola*	*Neurotrichus gibbsi*	1	20 30

when animal matter was offered, but was available with the mushrooms.

Results and Discussion

Tree Seeds

Short-term tests

Throughout the food tests, responses of *S. vagrans* and *S. trowbridgii* were similar. Neither species displayed a choice between seeds of Douglas fir (*Pseudotsuga menziesii*) and western white pine (*Pinus monticola*) or between Douglas fir and Sitka spruce (*Picea sitchensis*) in the encounter/preference (Table 1) and hourly tests (Table 2). A definite preference was shown, however, for those three seed species relative to noble fir (*Abies procera*) and Pacific silver fir (*A. amabilis*) seeds.

Thus results of these short-term tests indicate that true fir seeds were not eaten readily or at least were not preferred food, even though they are larger than the other seeds offered (Table 2); this may be associated with my observations that *Abies* seeds have a strong odor and that many are coated with resin.

Hoarding behavior was exhibited by *S. vagrans* during the hourly tests and by *S. trowbridgii* during the encounter/preference tests. Hoarding occurred in several individuals of both species and did not appear to be correlated with time of day or previous absence of food. On one occasion a Trowbridge Shrew removed and cached 67 sunflower seeds, offered in lots of 10, in 20 min. Although seed hoarding has not been reported in shrews and may be an artifact of captivity, hoarding of earthworms by *S. vagrans* has been noted (Broadbooks 1939).

Neurotrichus exhibited a definite preference for Sitka spruce, the smallest tree seeds available (Table 2). This marked preference of *Neurotrichus* for the smallest seeds indicates that it is not restricted to larger food items, and may be an important competitor for seeds with the smaller shrews.

Since hourly tests were conducted during different times of the day and night and lasted from 10 to 17 h, the numbers of seeds removed by the animals during each hour interval gave an indication of the activity and metabolic needs of the animals for a 24-h period. Results from these tests indicate that these animals are active at all times of day and have no long rest period. Ingles (1960) has also found that *S. vagrans obscurus* is active except for brief naps.

Long-term tests

Sorex trowbridgii removed significantly fewer seeds ($P < 0.001$) than *S. vagrans* during the hourly tests (Table 2), yet their seed consumption was similar for the 12-h tests (Table 3). *Neurotrichus* also removed fewer seeds during the hourly tests than during the long-term tests. These results indicate that the external disturbances of the hourly tests may have affected *Neurotrichus* and *S. trowbridgii* more than *S. vagrans*.

The long-term tests also indicated that true fir seeds are an acceptable, though not preferred, food source for the shrews. Although significantly fewer *Abies* seeds were removed by *S. trowbridgii* and *S. vagrans* during the hourly

TABLE 2—Preferences exhibited during hourly tree seed tests. Twenty seeds of each species were available to each animal at the beginning of every hour. Two animals were involved in each test. G-test expected frequencies for each group = total seeds eaten/number of tree species

Tree species compared	Average number of seeds removed per hour			Number of replications	Mean weight of a seed (N = 100) in mg
	Neurotrichus gibbsi	*Sorex trowbridgii*	*Sorex vagrans*		
Pseudotsuga menziesii,	0.06	5.39	10.05	54[1]	13.25
Picea sitchensis	12.16**	6.50	12.20		2.32
Pseudotsuga menziesii,	1.71	3.92	5.01		13.25
Picea sitchensis,	7.00*	5.38	5.50	28	2.32
Abies procera	0.18	0.85	1.90		38.10
Pseudotsuga menziesii,	1.33	3.66	6.27		13.25
Picea sitchensis,	7.97**	3.26	7.89**	30	2.32
Abies amabilis	0.61	0.53	0.33		35.35
Pseudotsuga menziesii,	1.33	3.66	6.27	30	13.25
Abies amabilis	0.61	0.53*	0.33**		35.35
Pseudotsuga menziesii,	1.71	3.92	5.01	28	13.25
Abies procera	0.18	0.85*	1.90		38.10
Picea sitchensis,	7.97	3.26	7.89	30	2.32
Abies amabilis	0.61**	0.53*	0.33**		35.35
Picea sitchensis,	7.00	5.38	5.50	28	2.32
Abies procera	0.18**	0.85*	1.90		38.10

* $P<0.05$.
** $P<0.01$.
[1] One *Sorex trowbridgii*, 27 replications.

tests ($P<0.005$), no difference was shown between *Abies* and other tree seeds for the 12-h tests ($P>0.1$).

Herb and Shrub Seeds

A summary of results with all herb and shrub species offered is given in Table 4. A 'Q' indicates that the seeds had been disturbed by the animal, but it is questionable whether any seeds were eaten. Shrews, and particularly *Neurotrichus,* commonly walked around in the seed pan, eating some seeds, kicking others about, and defecating. Because of this behavior and the small size of some seeds, it was often possible to determine only that a few seeds had been eaten.

There seems to be no relation between availability of these seeds to shrews and whether they were consumed. Many of the herb seeds

TABLE 3—Food removed by *Sorex* and *Neurotrichus* during the 12-h seed tests. Number of animals in each test is given in parentheses. A dash indicates that no test was made with that species. As *Neurotrichus* scattered proffered dog food about the cage, amounts for this animal were unobtainable

Foods compared	Amount of food given	Average amount of food removed		
		S. vagrans (4)	*S. trowbridgii* (4)	*N. gibbsi* (2)
Test #1				
Pinus monticola	20 seeds	20.0 seeds	20.0 seeds	—
Abies amabilis	20 seeds	14.0 seeds	13.25 seeds	—
Pseudotsuga menziesii	20 seeds	19.75 seeds	19.25 seeds	—
dog food	*ad lib.*	1.52 g	2.16 g	—
Test #2				
Pinus monticola	50 seeds	37.25 seeds	50.00 seeds	50.00 seeds
Pseudotsuga menziesii	50 seeds	37.50 seeds	50.00 seeds	50.00 seeds
dog food	*ad lib.*	0.60 g	1.52 g	unknown

TABLE 4—Qualitative results of herb, shrub, and mushroom experiments. Key: O = not eaten, Q = probably not eaten (see text), X = eaten. An asterisk in a column indicates that only one individual of that species was used in that particular seed test. A dash indicates no test was made with that species

Food offered	*Sorex vagrans*	*Sorex trowbridgii*	*Neurotrichus gibbsi*
Herbs			
Chrysanthemum leucanthemum	X	X	X
Cirsium sp.	X	X	X
Digitalis purpurea	O	O	O
Lamium purpureum	X	X	X
Latuca saligna	X	X	X
Lilium columbianum	Q	X	Q
Lupinus latifolius	X	Q	X
Plantago sp.	X*	X*	Q
Ranunculaceae (one species)	X	X	X
Rumex obtusifolius	Q*	Q*	X
Taraxacum officinale	X	X	X
Shrubs			
Berberis nervosa	X	Q	X
Gaultheria shallon	X	X	X
Rubus leucodermis	X	X	X
Vaccinium parvifolium	O	X	X
Mushrooms			
Agaricus hondensis	X	Q	X
Agaricus nivescens	X	X	X
Boletus zelleri	O	O	X
Cerosa sp.	—	X	—
Helvella lacunosa	O	O	X
Hygrophorus subalpinus	X	X	X
Laccaria laccata	O	O	Q
Lactarius deliciosa	O	X	X
Russula brevipes	X	X	X
Spropharia ambigua	O	Q	X

offered occur in disturbed areas such as roadsides and forest openings, and the forest species *S. trowbridgii* and *Neurotrichus* may have had no previous contact with them. Yet only one herb species, *Digitalis purpurea,* was avoided by all three species. This was also the smallest seed offered, so it is unknown whether it was rejected because of its size or its chemical nature.

Vaccinium parvifolium was not eaten by *S. vagrans.* This plant is a common species in forests and forest edges, but it is possible that *vagrans* was unable to penetrate the outer skin of the fruit. This interpretation is supported by the fact that plump ripe berries of both *Gaultheria shallon* and *Berberis nervosa* were left untouched whereas older shriveled ones were eaten.

The ability of the shrews to bite into some berries, and to open seed cases may be a factor that limits their food supply. For instance, some *Lactuca saligna* fruits with enclosed seeds were offered and other seeds were removed and then presented. The free seeds were eaten rapidly by all three insectivores. Less than 20% of the fruit capsules were opened by the shrews, although all were opened by *Neurotrichus.* As with the tree seed experiments, those with herbs and shrubs suggest that these insectivores will eat almost any food they can handle.

Mushrooms

Table 4 also provides the results of the mushroom tests. This was a very limited sample and included only mushrooms known to be non-poisonous to humans. *Neurotrichus* readily ate all but one of the species of mushrooms offered, but the two shrews were more selective. *Sorex trowbridgii* ate substantial amounts of five species of mushrooms while *S. vagrans* merely nibbled on them.

Animal Matter

Although the shrews and the shrew moles readily ate the chicken dog food, they all preferred other live or dead animal matter. All of the captive animals ate earthworms; larval, pupal, and adult forms of mealworms; sowbugs; aphids; lepidopterous pupae; maggots and other insect larvae infesting a rotting mushroom (*Armillaria mellea*); as well as small slugs (*Prophysaon andersoni* and *Arion ater*) and slug eggs (*Arion ater*).

Neurotrichus readily ate dead Deer Mice (*Peromyscus maniculatus*) and Rufous-sided Towhee (*Pipilo erythrophthalmus*), large slugs (*Ariolimax columbianus*), large black centipedes, and large beetles. One shrew mole failed to catch an active spider. *Sorex vagrans* ate termites, ants, spiders, and some carrion, but did not eat large black carabid beetles. *Sorex trowbridgii* ate termites, ants, small centipedes and millipedes, and an injured butterfly.

Conclusions

Studies of food habits indicate that these animals are generalists with regard to food. None of the animal matter offered to these animals was refused and *Digitalis purpurea* was the only seed that was definitely not eaten by any of the insectivores studied. In general, these animals ate a portion of all food items offered to them, even those with which they may have had no previous experience. Two species of tree seeds, *Picea sitchensis* and *Pinus monticola* were eaten in large quantities by all of the animals, even though these trees occur only sporadically in this vegetation zone (Franklin and Dyrness 1973). The conclusion that these animals are food generalists corresponds with what is known about their metabolic requirements: a large amount of food relative to size is required and it would be selectively advantageous for them to eat anything that is available which provides sufficient nutrition or energy.

This study indicates no distinct divisions between the species of insectivore and the sizes of acceptable food items. *Neurotrichus,* the largest animal studied, accepted and preferred the very small *Picea sitchensis* seeds. It was also capable of eating much larger food items, however, than were *S. vagrans* and *S. trowbridgii. Sorex vagrans* experienced the most difficulty in handling larger food items and those with heavier seed coats or exoskeletons. Therefore larger food items are available to *Neurotrichus* which are either less available or unavailable to the shrews.

No measure of the total amount of food available to these animals exists, so it is unknown whether food is a limiting factor to their growth and distribution. These food tests indicate, however, that there is a large overlap in acceptable food items of these shrews and shrew moles and suggests that competition for food may occur in areas where these animals coexist.

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Nesting Behavior and Food Habits of Parasitic Jaegers at Anderson River Delta, Northwest Territories

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Martin, Marilyn and Thomas W. Barry. 1978. Nesting behavior and food habits of Parasitic Jaegers at Anderson River delta, Northwest Territories. Canadian Field-Naturalist 92(1): 45–50.

Based on the seven nests located at Anderson River delta in 1973, Parasitic Jaegers (*Stercorarius parasiticus*) had a breeding density of 1 pair per 2300 ha. Breeding success was 14.3%. Males and females shared incubation. A chick at one nest was unattended by an adult only 8% of the time. Defended core areas were within a 300-m radius of the nest, although hunting areas extended at least 3 km. Bird remains, particularly passerines, were found in 85.0% of the pellets collected. Mammals, mainly microtine rodents, were in 25.4% of the pellets. Other food included eggs, insects, and berries.

Parasitic Jaegers (*Stercorarius parasiticus*) have a breeding range in North America that in part overlaps with that of Pomarine (*S. pomarinus*) and Long-tailed Jaegers (*S. longicaudus*). Pitelka et al. (1955) and Maher (1974) have studied the ecology of these three species of jaegers in Alaska where they are sympatric. The Parasitic Jaeger was the only species of jaeger breeding in the Anderson River delta, Northwest Territories (69°42′N, 129°00′W). The other species occurred only as migrants (MacFarlane 1891; Höhn 1959; Barry 1967). We studied nesting Parasitic Jaegers in this area where they were free from interactions with other jaeger species. This paper reports their nesting behavior and food habits in 1973 at the Anderson River delta.

Study Area and Methods

The study area is shown by the delta boundary in Figure 1. A detailed description of the physical features and vegetation of the delta is given by Barry (1967). Parasitic Jaegers and Glaucous Gulls (*Larus hyperboreus*) are the principal avian predators in the delta. There are nesting colonies of Lesser Snow Geese (*Chen caerulescens caerulescens*) and Black Brant (*Branta bernicula nigricans*) and scattered nests of other birds throughout the area.

In 1973 we searched the 16 300-ha delta, by boat and on foot for nesting jaegers, which make themselves conspicuous by their characteristic defence display when their nests are approached. Nests were located and visited regularly to record their nesting chronology. We bow-trapped three adults while they were incubating and color-marked them with spray paint to enable us to make observations on their hunting areas. We built an observation tower near nest 1 (Figure 1), from which we recorded data on incubation, chick care, defensive behavior, and hunting habits.

Additional observations were made of jaegers hunting over the nearby goose colony. Regurgitated pellets and loose food items were collected from the core areas of nesting pairs. Individual food items were identified to species when possible.

Additional field observations of Parasitic Jaegers from other years are included where applicable.

Results and Discussion

Breeding Biology

The first Parasitic Jaeger arrived at the Anderson River delta between 25 May and 1 June from 1953 to 1972. The first arrivals in 1973 and 1974 were on 27 May. The estimated maximum pre-laying period for the pair that laid first was only 7 days. This supports Maher's (1974) conclusion that for arctic nesting Parasitic Jaegers, the pre-laying stage is much shorter than the 3 weeks Perry (1948) reported for jaegers in Britain.

The chronology for each of seven nests located is given in Table 1. At each nest only a few days

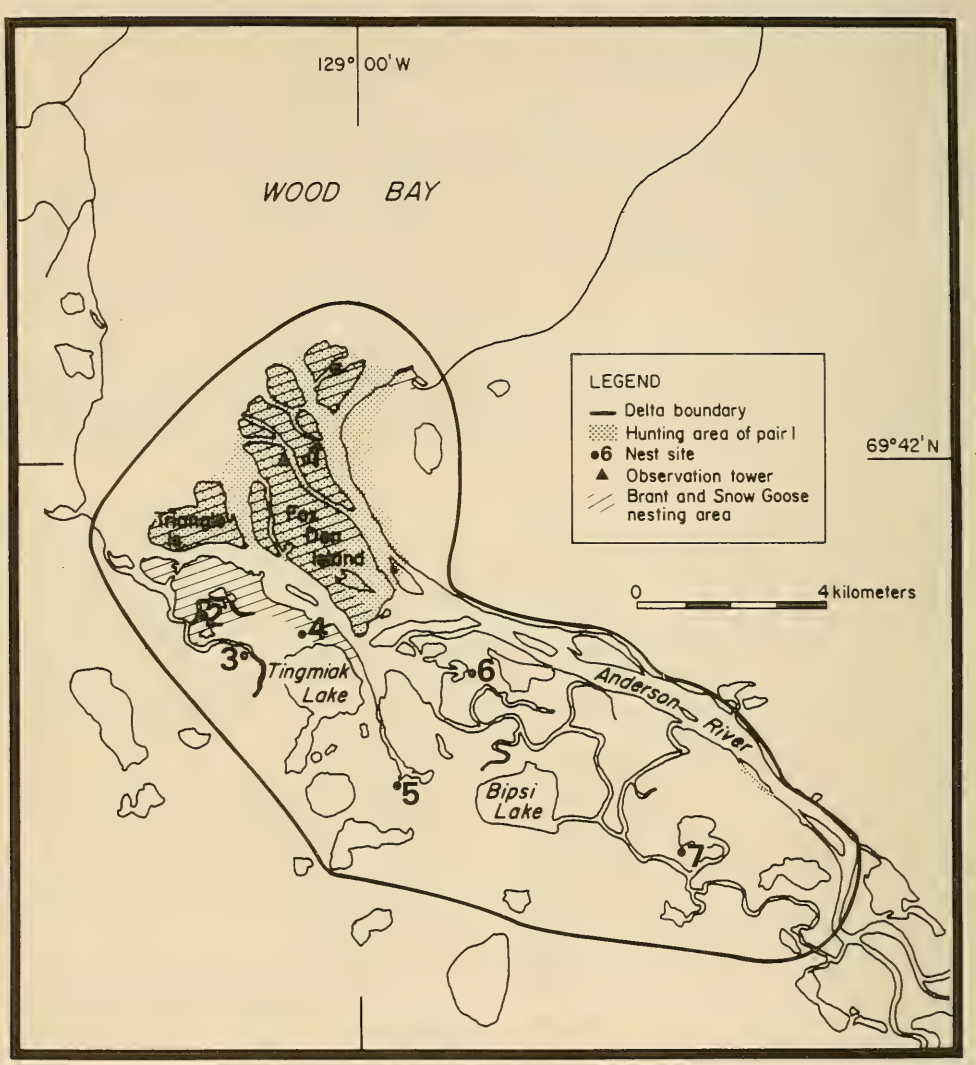

FIGURE 1. Location of Parasitic Jaeger nests and hunting area of pair 1 at Anderson River delta in 1973.

after the eggs had hatched, the younger chick could not be found. Nesting success, involving two chicks fledging from 14 eggs, was 14.3%. Both predation and differential chick mortality contributed to the poor breeding success in 1973. Both chicks that fledged were still present in the core area and were accompanied by an adult on 10 August. The chicks moved away from the nest within a day or two of hatching so that growth data was difficult to collect; however, one chick weighed 400 g at fledging and the other 425 g. Their ability to fly improved rapidly. On several occasions they were seen chasing their parents.

The nesting density of jaegers at Anderson River in 1973, using the total area of the delta, was 1 pair per 2300 ha. This was similar to the low breeding densities found elsewhere by Maher (1974) and Taylor (1974). In 1973 we observed a maximum of 10 jaegers whose nests we failed to find or which were pre-breeders, non-breeders, or failed breeders. The numbers of these birds can vary greatly as in 1959, when 50–60 non-nesting jaegers fed over the goose colonies. Taylor (1974) reported relatively constant numbers of non-breeders each year on Bathurst Island where there were few geese. In

TABLE 1—Nesting chronology for Parasitic Jaegers at Anderson River, Northwest Territories in 1973

Nest	Clutch size	Date of laying of first egg	Hatching date	Fledging date
1	2	June 8*	July 5	Disappeared July 20
2	2	Taken by a wolf	—	—
3	2	Infertile or "embryonic death" June 9*	July 6	August 4
5	2	June 3*	June 30	July 29
6	2	Disappeared before hatching	—	—
7	2	June 7*	July 4	Disappeared July 15

*Date estimated from hatching (accurate to 1 or 2 days).

1974 three jaeger pairs occupied the same areas but no nests were found. In 1974 arctic-breeding species generally had poor success because of bad weather.

The distances between the nest sites ranged from 900 to 7200 m as measured from aerial photos. Inter-nest distances varied widely and the sites were distributed unequally over the area (Figure 1). Nests 1, 2, 3, and 4 were concentrated in or near the goose colony. Similarly, Angstadt (1961) reported Parasitic Jaegers nesting on the periphery of a Blue Goose colony at McConnell River, Northwest Territories.

The distances between nests do not appear to reflect the defended area of Parasitic Jaegers. Breeding jaegers defended only a small area around their nests. Pair 1 defended a core area with a radius of about 180 to 300 m around their nest. The core area defended by other pairs appeared to be approximately the same size. Maher (1974), at Cape Sabine, found that pairs defended a core area with a radius of 183 to 275 m from the nest. He also observed territorial displays away from the core area; we did not see these displays. We observed other jaegers hunting without interference outside the core area and found that one member of a nesting pair often joined a hunting party when it passed near its core area. Breeding pairs did not challenge strange jaegers except at the core and even then jaegers were allowed closer than other avian species.

The known hunting area of pair 1 is shown in Figure 1. They were seen at least 3 km from their nest and may have travelled farther but they were no longer visible to us beyond 3 km. When there was a disturbance on the core area the hunting bird of pair 1, if it was nearby, would return to join in the defense. Often only one bird was present during our visits to other nests, suggesting that members of these pairs were also foraging at some distance from the core area. Parmalee et al. (1967) and Taylor (1974) note that Parasitic Jaegers defend a relatively small area during the breeding season and do their hunting at some distance from the core area.

Nesting Behavior

During 40 h of observation of pair 1 between 30 June and 4 July 1973, the color-marked parent incubated the nest 55% of the time. Its mate performed 45% of the incubation, indicating that parent birds share incubation duties about equally. The period of attentiveness varied from 15 to 110 min but usually lasted at least 1 h. Incubation periods of shorter duration were usually the result of interruptions by intruders (e.g., other jaegers, gulls, Golden Eagles (*Aquila chrysaëtos*)).

Normally the relieving bird glided toward the nest, and the incubating parent flew up seconds before its mate landed. It is possible that they vocalized during this period to achieve synchronization.

Pair 1 was observed, after their eggs had hatched, for a total of 21 h between 6 and 19 July. The color-marked parent remained in the core area 92% of the time. The other adult was present in the core area 38% of the time. The chick was alone only 8% of the time. At the other jaeger nests visited, the chick was never found alone even 12 days after fledging and was always found attended by the same adult, contrasting with Maher's (1974) findings that chicks were

alone 50% of the time.

During the incubation period, both adults of pair 1 hunted when they were not incubating. They did not share food until the day the first chick hatched. The color-marked bird begged from its mate, who regurgitated food. Subsequent to this, regurgitation was seen frequently. At other times the pair was observed to cooperate in pulling prey apart, with both taking a share. The color-marked parent sometimes left the core area to assist its mate in hunting or with an already initiated chase.

Aggressive behavior and the distraction display were strongly developed at the onset of incubation. As a human approached the core area the birds stood alert. Within 75–100 m of the nest the birds usually began their distraction display which consisted of vigorous wing-flapping, jumping, and loud whimpering. They performed on the ground and also in nearby ponds. As the human reached approximately 20–30 m from the nest an aggressive attack began. The bird generally flew in low from behind the intruder and frequently hit him with its wings and feet while it was in flight. There was much individual variation in these performances. The color-marked adult of pair 1 was always the more aggressive of the two, initiating most displays and continuing them longer. The other two color-marked jaegers were also more aggressive than their mates. This indicates there are differences in defensive behavior between individuals of a pair. Some pairs were more aggressive than others in the intensity and length of display. The amount of aggression decreased with the number of our visits.

Parasitic Jaegers also showed aggression toward Arctic Terns (*Sterna paradisaea*), Black Brant, Glaucous Gulls, Golden Eagles, other Parasitic Jaegers, Common Ravens (*Corvus corax*), Whistling Swans (*Olor columbianus*), Barren-ground Caribou (*Rangifer tarandus*), dogs (*Canis familiaris*), and a float plane.

Food Habits

Prey items in 173 food pellets were identified during the study (Table 2). Bird remains occurred in 85.0% of the pellets; remains of mammals appeared in 25.4%. Passerines accounted for 81.4% of the identified bird remains and the other 18.6% were from shorebirds. Muskrat remains were all collected from one territory and were probably scavenged. Insect remains and berry skins and seeds always occurred in small amounts. Eggshells occurred in 15.6% of the pellets, most often in trace amounts. Grass was usually present in small amounts, probably picked up accidentally.

A large number of different food items were found among the loose food collected with the jaeger pellets. This material included eggs of ducks, geese, loons, and curlews; and the carcasses of an adult ptarmigan (*Lagopus* sp.), a young duck, and a small pike (*Esox* sp.). Parasitic Jaegers were also seen feeding on the eggs of Snow Geese, Black Brant, White-fronted Geese (*Anser albifrons*), Glaucous Gulls, Whistling Swans, Willow Ptarmigans (*Lagopus lagopus*), Lapland Longspurs (*Calcarius lapponicus*), and various ducks.

Quantities of blueberries (*Vaccinium uligi-(nosum*), cloud-berries (*Rubus chamaemorus*), and crowberries (*Empetrum nigrum*) grew around nest 5. As these ripened, more and more droppings appeared that were composed of berry seeds and skins. No other nests had droppings containing berries, but no other jaegers had large berry patches within their territories.

Many authors have reported Parasitic Jaegers as predators on birds (Sutton 1932; Clarke 1940; Angstadt 1961; Parmalee et al. 1967; Taylor 1974). The results of this study clearly indicate that birds, especially passerines, are a major food item, with microtine rodents being much less important. Maher (1974) found in Alaska that birds made up 82% of food items, with passerines predominating.

Jaegers can eat eggs without ingesting much of the shell, so eggs may be a more important food item for nesting jaegers than our analysis of pellets indicates. Many birds had already started nesting when jaegers arrived in the spring. Geese lay one egg a day for several days before incubation begins and are off their nests for considerable periods. Hunting jaegers were frequently seen at goose nests during this period. Opportunities for nest predation decreased when geese began incubation. Jaegers then depended on accidental disturbances in the goose colony. In 1973 we did not see jaegers trying to drive geese from their nests, although

TABLE 2—Frequency (%) of food items in 173 pellets of Parasitic Jaegers, Anderson River delta, Northwest Territories, 1973

Food items	Frequency (%)
Bird remains (total)	85.0
Charadriiformes	9.8
Long-billed Dowitcher (*Limnodromus scolopaceus*)	.6
Semipalmated Sandpiper (*Ereunetes pusillus*)	4.6
Passeriformes	42.8
Horned Lark (*Eremophila alpestris*)	1.7
Water Pipit (*Anthus spinoletta*)	1.2
Redpoll (*Acanthis* spp.)	.6
Savannah Sparrow (*Passerculus sandwichensis*)	5.2
Tree Sparrow (*Spizella arborea*)	1.2
White-crowned Sparrow (*Zonotrichia leucophrys*)	3.5
Lapland Longspur (*Calcarius lapponicus*)	2.3
Unidentified bird remains	32.4
Eggshell	15.6
Mammal remains (total)	25.4
Insectivora	.6
Shrew (*Sorex arcticus*)	.6
Rodentia	22.8
Red-backed Vole (*Clethrionomys gapperi*)	1.7
Meadow Vole (*Microtus oeconomus*)	6.9
Muskrat (*Ondatra zibethicus*)	5.8
Lemming (*Lemmus* spp.)	4.6
Collared Lemming (*Dicrostonyx* spp.)	4.0
Carnivora	.6
Weasel (*Mustela* spp.)	.6
Unidentified mammal remains	1.2
Fish remains	.6
Insect remains	18.5
Berries	14.5
Grasses	32.4

Barry (1967) has seen this. Angstadt (1961) reported groups of jaegers harassing incubating geese, with little success.

Most hunting jaegers occurred in groups of one to three with a maximum of five. During the period when geese were incubating, groups of jaegers were frequently observed flying low over the colony. Jaegers were often seen rummaging in goose nests for eggs or abandoned goslings during and several days after the goose hatch. One hill was crowded with 175 Snow Goose nests and a great number of eggs was seen outside the nests. Jaegers were unable to scavenge these eggs until the geese moved out of the area.

Parasitic Jaegers appeared promptly in the goose colony whenever a disturbance arose such as the passing of a helicopter or a Golden Eagle. Territorial fights among these geese provided jaegers with opportunities to prey on eggs. Barry (1967) found that visits to the goose colonies by Grizzy Bears (*Ursus arctos*), Red Foxes (*Vulpes vulpes*), and Arctic Foxes (*Alopex lagopus*) gave many opportunities for jaegers to feed on eggs. The mammals, feeding on eggs in one nest after another, frightened geese in their path, leaving the nests easy prey for jaegers. The same was true with human disturbances; jaegers would follow the field worker as he moved through the colony.

After the goose hatch was complete we often saw pair 1 chasing small birds, which they usually successfully caught. One bird often initiated a pursuit and was joined by the other. Sometimes the prey alighted in the grass; then, while one jaeger hovered, the other stalked the victim on the ground. If the prey flew away,

aerial pursuit began again. Pair 1 frequently walked through the grasses in their territory, and were likely catching insects.

During the 1973 study we witnessed a few incidents in which jaegers parasitized other species within their hunting range. On three occasions in the goose colony jaegers took food from Glaucous Gulls, but twice we saw gulls successfully pirate food from jaegers. Twice jaegers unsuccessfully attempted to steal fish from Arctic Loons (*Gavia arctica*) in flight and twice we saw them chasing Arctic Terns presumably for the same purpose. All these incidents involved adult jaegers. A chick that had fledged only 10 days earlier was seen attacking an Arctic Tern carrying a fish.

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Reproductive Success of Herring Gulls on Granite Island, Northern Lake Superior, 1975 and 1976

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The reproductive success of 200 pairs of Herring Gulls (*Larus argentatus*) that nested on Granite Island, northern Lake Superior in 1975 and 1976 is reported. The proportion of nests which hatched at least one egg was 96% in 1975 and 97% in 1976. Hatching success was 79.6% and 84.2% respectively. Disappearance and embryo failure were the main causes of egg mortality, 15.8% in 1975 and 12.4% in 1976. The number of fledged young per pair of nesting adults was calculated at 1.32 in 1975 and 1.55 in 1976. Examination of organochlorine and mercury residues in eggs showed generally that levels were below those recorded from Lakes Ontario and Michigan and above those from Lakes Huron and Erie. Based on this and concurrent studies on the Great Lakes Herring Gull population, no general relationship has been established between organochlorine residues and reproductive success in all Great Lakes populations of the Herring Gull.

Key Words: Herring Gull, reproductive success, pollution, Lake Superior.

Recently a number of papers have summarized the reproductive performance of Herring Gulls (*Larus argentatus*) that nest within the Canadian Great Lakes ecosystem (Gilbertson 1974; Gilbertson and Hale 1974a, b; Morris and Haymes 1977; Teeple 1977). The above authors have reported relatively low reproductive success compared to those of studies of eastern seaboard colonies (Kadlec and Drury 1968; Haycock and Threlfall 1975) and European colonies (Harris 1964; Parsons 1971). Much of the reproductive failure of the lower Great Lakes Herring Gulls was caused by high early embryonic death (Gilbertson and Hale 1974a), the disappearance of eggs, and poor survival of chicks (Gilman et al. 1977). Although the actual cause of the lower Great Lakes phenomenon is still enigmatic it has been associated with heavy contamination of eggs and tissues of adult birds with organochlorines, specifically DDE and polychlorinated biphenyls (PCBs).

Stimulated by the reports of poor reproductive success of Herring Gulls in the lower Great Lakes in 1973 (Gilbertson and Hale 1974b), we initiated a 2-year study of the nesting biology of the species at a colony in northern Lake Superior. This report represents the first documentation of the reproductive performance of the gulls over a two-season period from a northern Great Lakes region and serves as a means of comparison with current data from other colonies.

Study Area and Methods

The study was conducted on Granite Island (48°43′N, 88°29′W), a rock outcrop about 400 m by 200 m and 4.8 km from the closest mainland point northeast of Sibley Peninsula (see Ryder 1974, Figure 1). The island is a strongly undulating rock surface about 30 m above the surrounding waters of Black Bay. Over half the island is forested by Balsam Fir (*Abies balsamea*), White Cedar (*Thuja occidentalis*), and White Birch (*Betula papyrifera*). Approximately 150 pairs of Herring Gulls nest in the shrub and bare rock areas of the northwest part of the island. The east part of the island is used for nesting by about 1000 pairs of Ring-billed Gulls (*L. delawarensis*). There is virtually no overlap in the nesting area of the two species, although 5–10 pairs of Herring Gulls nested on the northwest and west borders of the Ring-billed Gull colony. The only mammals seen during our studies on Granite Island were Snowshoe Hares (*Lepus americanus*) and Red-backed Voles (*Clethrionomys gapperi*).

In 1975 and 1976 ice prevented us from visiting Granite Island before 13 May and 11 May respectively. On our initial visits, we marked the eggs in 100 Herring Gull nests with non-toxic felt marker pens. The remaining nests were either in dangerous locations (close to slippery rocks near deep water) or adjacent to the Ring-billed Gull colony where experimental studies were underway. Each nest was marked

by placing a numbered plastic strip, 50 cm long, either under the nest or securing it to a nearby bush or tree. We visited each nest two or three times a week to compile nest histories. We did not visit the colony during periods of excessive heat or cold as we assumed disturbances during such conditions would be detrimental to the eggs and/or young (see Nisbet 1975; Vermeer 1970). We web-tagged each newly-hatched chick with a numbered fingerling fish tag. We later banded each chick with an aluminum United States Fish and Wildlife Service leg band.

We collected 19 eggs in 1974 and 20 eggs in 1975 from three-egg clutches which were not part of our nesting studies. These eggs were used to determine the levels of organochlorine, polychlorinated biphenyls (PCBs), and mercury. Analyses were conducted by the Ontario Research Foundation (cf., Reynolds 1969).

We define terms used in this paper as follows: *hatching success*, the proportion of eggs laid which hatched; *reproductive success*, the number of chicks that survived to 21 days per pair of reproducing adults. Although a number of authors have used different ages of chicks to measure post-hatching survival of Herring Gulls (40–45 days, Keith 1966; 30 days, Morris and Haymes 1977; 15 days, Drury and Kadlec 1974; Nisbet and Drury 1972; 7 days, Parsons 1970) we used 21 days for fledging because, according to authors cited in and including Kadlec and Drury (1968), major mortality of Herring Gull chicks occurs during the first three weeks. Hunt (1972) considered young Herring Gulls to have survived the prefledging stage if they weighed 500 g. Data presented by Harris (1964) show that, depending on brood size, chicks reach this weight in about 20–24 days after hatching.

Results

In both years egg-laying was underway by the time we first visited Granite Island. The data in Table 1 are based on backdating 28 days when necessary from the dates eggs hatched (Haycock and Threlfall 1975). Approximately 80% of the nest sites used in 1975 were occupied in 1976. Seventy-five percent of the nests were located on sites adjacent to or on a vegetation substrate. The remainder were isolated from any vegetation (see Brown 1967).

The average clutch size was 2.99 ± 0.17 (SD) in 1975 and 2.98 ± 0.17 in 1976. Except for two 2-egg clutches in both years and one 4-egg clutch in 1975, all nests contained three eggs. Based on data presented in Gilman et al. (1977), the 1975 distribution from Granite Island differs significantly ($P < 0.05$) (larger) from those collected from Lakes Huron, Erie, and Ontario in that year. No comparable data are yet available for 1976 from these same locations. The Herring Gulls on Granite Island laid no single-egg clutches and renesting was virtually nonexistent during the study period.

Table 1 shows there was little relation between time of egg-laying and hatching success. In each year over 50% of the clutches hatched in a 5-day period, indicating a high degree of synchrony. In 1975, 96% of the nests hatched one or more eggs and in 1976, 97% of the nests were successful. Hatching success in the 2 years was 79.6% and 84.2% respectively. The high success of the 21–25 May in 1975 and 1976 and 28–30 April nesters in 1976 is most likely an artifact of the small sample size.

The fate of unhatched eggs is given in Table 2. Disappearance and embryo failure were the principal causes of egg mortality, although

TABLE 1—Egg-laying frequency and hatching success of Herring Gulls on Granite Island, 1975 and 1976

Date laid	Number of eggs laid[1]		Percent hatched	
	1975	1976	1975	1976
28–30 April	—	12	—	100.0
1–5 May	—	94	—	89.4
6–10 May	39	142	79.5	81.0
11–15 May	168	35	83.9	94.3
16–20 May	78	7	80.8	71.4
21–25 May	3	2	100.0	100.0

[1]The total differs from 299 eggs laid in 1975 (Table 2) because all eggs in four nests (11 eggs) did not hatch so that laying dates could not be calculated by back dating; similarly the 1976 total differs from 298 eggs laid because all eggs in two nests (6 eggs) did not hatch.

TABLE 2—Fate of unhatched Herring Gull eggs on Granite Island, 1975 and 1976

	1975	1976
Number of eggs laid	299	298
Hatched	238 (79.6)[1]	251 (84.2)
Failed to hatch	61 (20.4)	47 (15.8)
Disappeared	19 (6.4)	19 (6.4)
Embryo failure	28 (9.4)	18 (6.0)
Pipped and died	5 (1.7)	3 (1.0)
Cracked shell	4 (1.3)	5 (1.7)
Outside nest	5 (1.7)	2 (0.7)

[1]Numbers in parentheses are percentages of the total number of eggs laid.

embryo failure values were below those given by Gilman et al. (1977) for Lake Erie (16.7%) and Lake Ontario (35.1%), and Gilbertson and Hale (1974a, b) for Lake Ontario (20% and 22% respectively). Our data correspond closely in these two mortality categories with those of Haycock and Threlfall's (1975) Newfoundland study (6%).

Approximately two-thirds of the chicks we found dead each year succumbed before they reached 10 days of age. These findings are similar to the results reported by Paynter (1949), Harris (1964), Brown (1967), Kadlec and Drury (1968), and Hunt and Hunt (1976). We classified mortality as outlined in Table 3. Birds that were eaten in whole or in part we considered cannibalized, because several cases of this were observed, and no active avian or mammalian predators were seen on the island during the study. Head injuries are associated with territorial defense by adults when chicks wander onto their territories (Haycock and Threlfall 1975). Chicks found dead for no apparent reason are enigmatic. Although we cannot dismiss the possibility that these chicks may have died from disease, it would be misleading to associate these deaths to such a cause without additional data. Teeple (1977) found cloacal fecal impaction, diarrhoea, and malnutrition in dead chicks from Brothers Island, Lake Ontario, in 1973, but stated that autopsies gave no indication what caused these conditions. Chicks that we found dead in or close to their nests after heavy storms or rain were considered to have died of exposure.

The number of chicks calculated to have fledged per nesting pair was 1.32 in 1975 and 1.55 in 1976. These figures are based on our repeated sightings of live chicks to 21 days of age and on assumptions regarding the fate of the disappeared chicks. For the latter, we have assumed, based on our findings of dead, banded, known-age chicks, that two-thirds of the chicks that disappeared before they were 10 days old, were likely dead. Similarly, we have assumed that one-third of the chicks that were not relocated after they were 10 days old, had died.

The validity of the above assumptions is difficult to measure and remains open to discussion of post-hatching mortality patterns and fledging times of Herring Gulls. In that our searches for chicks on Granite Island were frequent and thorough, we are confident our calculated reproductive success closely depicts the actual survival of chicks. Values given for reproductive success at other Great Lakes locations (Morris and Haymes 1977; Teeple 1977) are all below the Lake Superior levels.

The data on organochlorine and mercury levels from all the Great Lakes Herring Gull samples from 1974 and 1975 have recently been reported in detail by Gilman et al. (1977). The general pattern of contamination with organochlorines puts Lake Superior intermediate between higher levels in Lakes Ontario and Michigan and lower levels in Lakes Huron and Erie (Gilman et al. 1977). Mercury residues recorded in 1974 and 1975 are similar to those

TABLE 3—Mortality of Herring Gull chicks on Granite Island, 1975 and 1976

	Number of dead chicks		Percent of total number of deaths	
Cause of death	1975	1976	1975	1976
Cannibalism	7	7	14.3	17.9
Head injury	5	14	10.2	35.9
No visible injury	32	14	65.3	35.9
Exposure	5	4	10.2	10.3

reported by Ryder (1974) and likely below toxic levels.

Discussion

The results of this study show that, compared to other Great Lakes colonies, the Granite Island Herring Gulls show a hatching success equivalent to or higher than those reported from colonies outside the Great Lakes ecosystem (see Morris and Haymes 1977). The high degree of synchrony of egg-laying and hatching coupled with the almost ubiquitous three-egg clutches on Granite Island have virtually eliminated wide variation which markedly affects reproductive success.

The task of determining why differences occur in the reproductive success amongst colonies in a large single ecosystem is difficult. This investigation and others referred to have only noted annual productivity via the best methods available. Factors such as colony stability, habitat safety (security from flooding and poor drainage), age, experience, pairbond characteristics, and many other factors all remain virtual unknowns in the large study area under review. To date, no agreement has been reached which links definitively environmental toxicants and reproductive success in this species in all its Great Lakes environments (see Morris and Haymes 1977, p. 805; Teeple 1977, p. 156).

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Bird Use of a Beaufort Sea Barrier Island in Summer

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The number and distribution of birds near a barrier island west of Prudhoe Bay, Alaska, were recorded during the phenologically "late" summer of 1972. During eastward (spring) migration, most birds were restricted to a small area of open water in the nearby river delta. Although numerous eiders (*Somateria* sp.) fed and rested in the island area during spring migration, few did so in late summer, when Oldsquaws (*Clangula hyemalis*) and Red Phalaropes (*Phalaropus fulicarius*) congregated near the island.

Key Words: Alaska, arctic, Beaufort Sea, birds, eider, loon, Oldsquaw.

Knowledge of bird use of Alaskan Beaufort Sea coastal waters is limited to a few offshore surveys (Bartels 1973; Frame 1973; Watson and Divoky 1974) and nearshore reconnaissance studies (W. T. Schmidt, unpublished report; Bartels 1973; Divoky et al. 1974; Watson and Divoky 1974; G. E. Hall, unpublished report). These studies all demonstrate the importance of nearshore coastal waters to birds, particularly sea ducks and phalaropes, in late summer. P. G. Connors (unpublished report) and D. Schamel (unpublished report) were the first to quantify seasonal changes in bird numbers along Alaska's north coast; both reported heavy bird use of nearshore waters in late summer.

Some nearshore areas of the Alaskan Beaufort Sea have already been leased to oil companies by the state of Alaska. In addition, a joint state and federal lease sale is tentatively planned for this area in 1979. With the imminent expansion of oil development to numerous barrier islands along this coast, the extent to which birds rely on nearshore waters needs documentation. This paper documents changes in bird numbers over time and space near a barrier island during a single summer.

Study Area and Methods

The study was conducted 20 May – 12 August 1972 from a temporary camp on Egg Island, Alaska (70°26′N, 148°43′W), a barrier islet on the Beaufort Sea coast, 8 km northwest of Prudhoe Bay and 4 km northeast of the Kuparuk River delta (Figure 1). The island is small (7.5 ha) and flat (maximum elevation 1.7 m) and is comprised of sand and gravel. Only four plant species were found: *Honckenya peploides* (sandbeach sandwort), *Mertensia maritima* (oysterleaf), *Elymus arenarius mollis* (lyme grass), and *Puccinellia phryganodes* (alkali grass). During winter and early spring the island is icebound. After spring break-up the north shore is exposed to the action of waves and ice. Although tide fluctuations for this area average 15 cm, changes in wind direction and velocity can cause greater variations in water level.

In 1972, overflow waters from the Kuparuk River reached Gwydyr Bay (Figure 1) on 1 June. By 6 June the overflow was beginning to drain through holes in the ice, and by 10 June some previously flooded areas of bay ice were dry. On 14 June Kuparuk River water was cutting a large lead in the bay ice west of Egg Island. By 16 June the lead had extended eastward, to include the southwest end of the island, and northward into the sea. The entire south shore of the island was ice-free on 20 June and 70% of the bay was ice-free by 28 June.

Gwydyr Bay is considerably shallower than the adjoining section of the Beaufort Sea. Water depths in the bay range from 1.0 to 2.5 m; depths at sea range from 2.0 to 5.0 m in the study area. Tidal movement temporarily concentrates marine invertebrates by forcing them through narrow (5–10 m wide) and shallow (0.3–1.0 m deep) areas between the gravel islands. Birds and fish (arctic char, *Salvelinus alpinus*) are drawn to these passes to feed upon mysids, amphipods, and isopods.

Censuses were made by two individuals (one observer and one recorder) from 12 June through 7 August 1972, using a 20× spotting scope from an elevated blind on Egg Island. During a census count (an observation period) all birds within a 1.8-km radius (Figure 1) were identified with respect to species, sex, location,

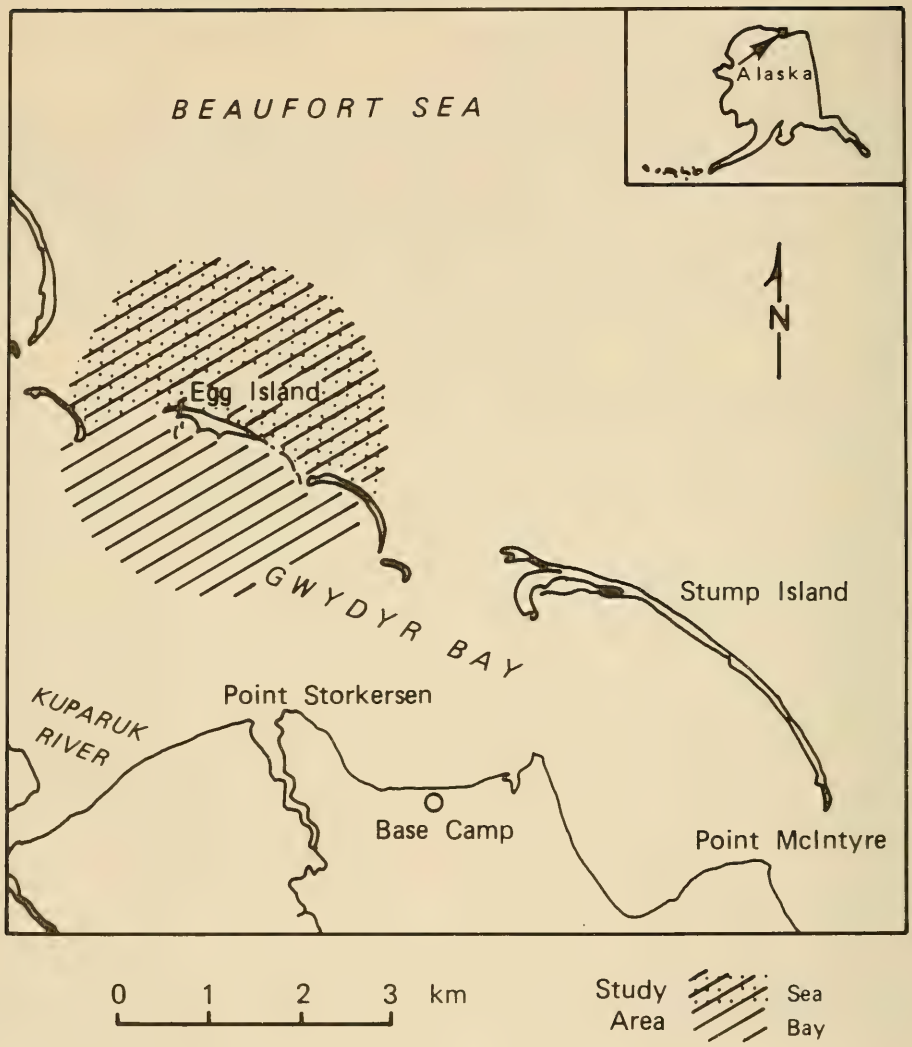

FIGURE 1. Map of study area, Egg Island, Alaska.

and activity. The 10.2-km² study area was subdivided into three regions: sea (5.3 km²), islands (0.2 km²), and bay (4.7 km²). The duration of a census count varied from 20–40 min (early June) and 50–70 min (July and August) to 90–110 min (late June), depending upon bird numbers in the area. The variable duration of the counts does not invalidate the data, since most birds were sedentary during censuses.

Most observed migratory movements occurred seaward of the study area. Eighty-four hours of census data were analyzed. The census schedule is summarized in Figure 2. Variable censusing effort is partly due to frequent bad weather; no censuses were conducted when fog obscured any part of the study area. In addition, censuses were minimized when eiders were active on the island, since their activities formed my primary study (Schamel 1974, 1977).

Results and Discussion

Several species occurred in large numbers, at least seasonally, or were ubiquitous in the nearshore area. These include Yellow-billed Loon (*Gavia adamsii*), Arctic Loon (*Gavia arctica*), Red-throated Loon (*Gavia stellata*), Common

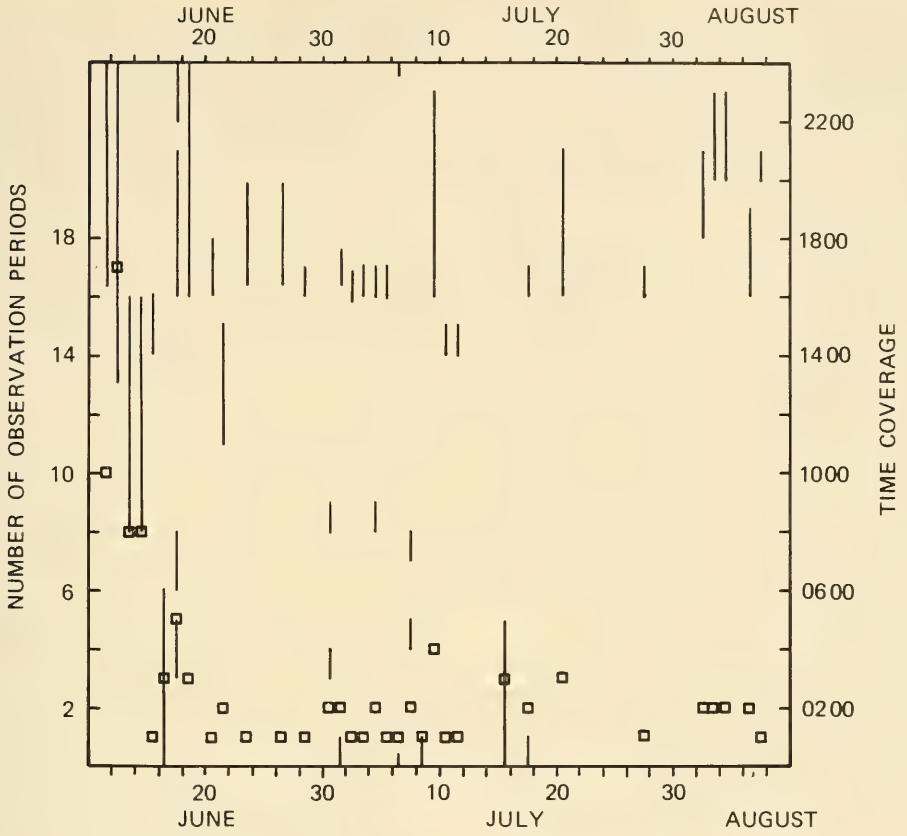

FIGURE 2. Daily number (square) and time coverage (line) of observation periods.

Eider (*Somateria mollissima v-nigra*), King Eider (*Somateria spectabilis*), Oldsquaw (*Clangula hyemalis*), Red Phalarope (*Phalaropus fulicarius*), Glaucous Gull (*Larus hyperboreus*), and Arctic Tern (*Sterna paradisaea*).

The summer of 1972 was phenologically "late" in the Prudhoe Bay area. The mean hatching date of eider nests on Egg Island was 6 days later than in 1971. Similar phenological delays were recorded in the Prudhoe area in 1972 for tundra-nesting waterbirds (Bergman et al. 1977) and insects (MacLean 1975). In "late" summers fewer nests are initiated, smaller clutch sizes prevail (Barry 1960), and renesting is less likely than during "normal" summers. Thus, production of young and the summer activity patterns and distribution of birds may vary greatly between phenologically "normal" and "late" summers. The reader is cautioned that data presented here were not collected during a "normal" summer.

Loons

Numbers of loons (all species) peaked on 16 June (3.9 birds/km^2) and thereafter decreased steadily. On the last census, 7 August, only one loon was seen in the study area. The occurrence of loons in large numbers near Egg Island during mid-June was probably due to limited open water and, therefore, limited feeding areas, and to the presence of spring migrants. The dwindling number of loons in the island area thereafter was probably due to the availability of food resources inland and in other areas along the coast (inland ponds thawed about 20 June 1972 (Howard 1974)).

Throughout the summer, more loons were found at sea ($\bar{x}$ = 1.6 birds/km^2) than in the bay ($\bar{x}$ = 0.6 birds/km^2). The heterogeneity chi-square test (Zar 1974) isolated three portions of the summer that could justifiably be pooled for normal chi-square analysis: 12 June – 10 July, 11–27 July, and 28 July – 7 August. Signifi-

cantly more loons used the sea from 12 June to 10 July than the bay ($\chi^2 = 92.2$, $P < 0.001$). During the period 11–27 July, both areas received equal use ($\chi^2 = 0.07$, $0.90 < P < 0.95$). Slightly more loons were observed in the bay (8) than the sea (5) from 28 July to 7 August, although this relationship could not be tested statistically.

Loon numbers showed a daily pattern. These birds were most numerous near the island from 0800 to 1600 hours and least numerous from 2000 to 0200 hours (Alaska Daylight Time). During late night and early morning hours, I observed that loons are most common on inland lakes and ponds where they were nesting.

Eiders

Small numbers of eiders were seen in the study area beginning on 2 June, 1 day after the waters of the Kuparuk River (Figure 1) overflowed onto the Gwydyr Bay ice. Small numbers of eiders were present in the study area before censusing started on 12 June.

Eastward (spring) eider migration apparently occurs largely offshore (Barry 1968; S. R. Johnson, personal communication). At Oliktok Point, 25 km west of Egg Island, Flock (1973) recorded heavy eastward migration at sea in late May 1972. I saw the fringe of heavy movements on 4 June, more than 2 km north of Egg Island. At this time few eiders (< 1 bird/km^2) were seen in the study area, which was still ice-covered. As shore leads opened, eiders became more numerous near barrier islands. Eider numbers in the study area rose quickly from 12 June (0.3 Common Eiders/km^2; 0.8 King Eiders/km^2) to a peak on 18–19 June (25.7 Common Eiders/km^2; 56.7 King Eiders/km^2), then decreased rapidly. By 27 June only 2.9 Common Eiders/km^2 and 14.9 King Eiders/km^2 were seen. Numbers continued to decrease throughout the field season. On 7 August, the date of the last census, no birds of either species were seen. Almost all migrants were found on open water at sea; few used the bay.

Eiders were present on barrier islands from 18 June to 4 August. Peak numbers occurred from late June through mid-July (about 100 Common Eiders/km^2; about 50 King Eiders/km^2). Birds on the islands represented nest-initiating pairs, incubating females, and non-breeding females. I located 39 Common Eider nests and 3 King Eider nests on Egg Island in 1972, of which 33% produced young (Schamel 1974, 1977).

Westward (post-breeding) migration through the study area began in early July (Schamel 1974). As in the Canadian Beaufort Sea (G. F. Searing et al., unpublished report), concentrations of eiders did not occur in nearshore waters during westward migration (about 1–2 eiders/km^2 in late July), probably for two reasons: (1) westward migration extends over 2.5 to 3.0 months, whereas eastward migration is concentrated within 1.5 to 2.0 months, and (2) in spring, open water is limited and birds congregate where leads are available, whereas in summer open water occurs along almost the entire shoreline and birds are able to disperse. Bartels (1973) flew aerial surveys and made shipboard observations from Barrow to the Sagavanirktok River delta (just east of Egg Island) from mid-August through mid-September 1971. He found the greatest concentration of eiders 13–16 km from shore. Within 8 km of shore, the mean eider density was 1.6 birds/km^2. The highest concentration of eiders he reported was 4.1 birds/km^2.

Oldsquaws

Oldsquaws showed a general numerical increase from mid-June through early August. Small numbers of Oldsquaws were seen during June (about 1–13 birds/km^2). Numbers increased rapidly from early through mid-July (about 37–70 birds/km^2), then increased only slightly. The rapid increase in early July probably represented the arrival of males from inland nesting areas and the arrival of late non-breeding migrants. The sex ratio in a flock of 130 Oldsquaws nesting on Egg Island on 5 July was 2.9 males:1.0 females. With the end of inland nesting in mid-July, additional males moved to the coast (Bergman 1974).

Oldsquaws began molting in mid- to late July. Molting birds seemed to prefer the bay (lee) side of the island. More than 90% of the Oldsquaws were found at sea until early July; thereafter, coincident with molting, an increasing proportion used the bay. Approximately 80% of the Oldsquaws were found in the bay by August.

The late summer aggregation of Oldsquaws in nearshore waters seems to be a common phenomenon on the Beaufort Sea coast. Bartels (1973) found Oldsquaws concentrated (173

birds/km^2) 3–8 km from shore in late summer. Early August densities for the Gwydyr Bay in 1972 were 70–189 Oldsquaws/km^2. Elsewhere, W. T. Schmidt (unpublished report) estimated 6000 Oldsquaws in a bay near Nuvagapak Point, Alaska, near the Canadian border in late August 1970, and G. E. Hall (unpublished report) noted a single flock of 5000 birds in Simpson Lagoon, about 25 km west of the study area, in mid-August 1971. Vermeer and Anweiler (1975) counted 2450 Oldsquaws in late August 1973 near Herschel Island, Yukon Territory.

Red Phalaropes

Red Phalaropes are shorebirds that spend the non-breeding season at sea and June migrants were observed flying from the sea towards the coast. Peak phalarope numbers in mid-June (about 1.5 birds/km^2) in the study area coincided with the start of nesting inland in 1972 (Bergman et al. 1977). The small number of phalaropes seen in the study area in late June (< 0.1 bird/km^2) corresponded to the departure of females from the breeding grounds (Bergman et al. 1977). In early August young phalaropes flew to the coast, where they congregated in nearshore waters (about 8 birds/km^2; they apparently are also found at least 80 km out to sea at this time (Frame 1973). Farther west, at Barrow, Red Phalaropes follow a similar pattern of seasonal habitat use (P. G. Connors, unpublished report).

Glaucous Gulls

These birds were present in the study area throughout the entire field season at a maximum of 3–4 gulls/km^2. Only three pairs of Glaucous Gulls nested on Egg Island in 1972, of which two pairs successfully hatched eggs. All young disappeared from the island within 10 days of hatching. With the exception of one day in mid-July, gull numbers steadily declined from late June through August. These birds apparently moved to offshore areas (see Watson and Divoky 1974). Frame (1973) saw few Glaucous Gulls in offshore waters during early August 1969, suggesting that the early departure from nearshore waters in 1972 may have been caused by breeding failures. Watson and Divoky (1974) reported poor reproductive success in Glaucous Gulls on barrier islands along the Alaskan Beaufort coast in 1972.

Arctic Terns

Arctic Terns were first noted on 2 June. By 9 June some were displaying and forming nest depressions on the island. Peak tern numbers in mid-June (about 1.5 birds/km^2) probably corresponded to the limited open water and, to a lesser extent, the end of spring migration. At this time, numerous terns were establishing territories on the island and feeding in nearby waters, mostly at sea. After 1 July, all but one pair had abandoned nesting attempts and departed from the study area. The remaining pair produced two young, both of which died less than a week after hatching. In 1972, only an occasional tern was seen after mid-July. Frame (1973) saw no terns in offshore waters in early August. Watson and Divoky (1974) recorded some terns in offshore waters through September. They also found few young terns on Beaufort Sea barrier islands in 1972.

Terns showed strong daily activity patterns. They were most numerous in the study area from 2200 to 0600 hours. During mid-day (1000 to 1200 hours) a mean number of less than one bird was seen. Terns are visual hunters and probably require good lighting for success. They spent the brightest part of the day foraging away from the island, returning at night.

Other Birds

Numerous Black Brant (*Branta bernicla nigricans*) migrated past Egg Island, but most movements occurred outside the study area. Few Surf Scoters (*Melanitta perspicillata*) were seen in the island area, although a group of 200–300 was seen in Harrison Bay in August 1971 (G. E. Hall, unpublished report), and Vermeer and Anweiler (1975) recorded up to 3200 in Herschel Island bay on 5 August 1973.

Other birds were seen only in small numbers in the Egg Island area in 1972. These included Canada Goose (*Branta canadensis*), Pintail (*Anas acuta*), Greater Scaup (*Aythya marila*), Spectacled Eider (*Somateria fischeri*), White-winged Scoter (*Melanitta deglandi*), Red-breasted Merganser (*Mergus serrator*), American Golden Plover (*Pluvialis dominica*), Ruddy Turnstone (*Arenaria interpres*), Dunlin (*Calidris alpina*), Semipalmated Sandpiper (*Calidris pusilla*), Pomarine Jaeger (*Stercorarius pomarinus*), Parasitic Jaeger (*Stercorarius parasiticus*),

Long-tailed Jaeger (*Stercorarius longicaudus*), Black-legged Kittiwake (*Rissa tridactyla*), Sabine's Gull (*Xema sabini*), Thick-billed Murre (*Uria lomvia*), Black Guillemot (*Cepphus grylle*), Snowy Owl (*Nyctea scandiaca*), redpoll (*Acanthis* sp.), and Snow Bunting (*Plectrophenax nivalis*).

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Recoveries of Saskatchewan-banded Great Horned Owls

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From 2229 flightless young Great Horned Owls, *Bubo virginianus*, that I banded in Saskatchewan, there have been 209 recoveries to date. Owls most commonly were shot, caught in traps, found dead, killed on highways, and electrocuted. Over half the recoveries were in the first year of life, and in the first six months most of these were within 10 km of the nest site. The oldest owl was trapped 13 years, 6½ months after it was banded. During years of decreased reproductive success, evidently related to decreased food supply, the owls move much farther than in "build-up years." Of the 36 recoveries beyond 250 km, 35 were in a remarkably consistent southeasterly direction.

Key Words: Great Horned Owl, banding, longevity, movements.

My owl studies grew innocently from random banding of any bird at hand, including 15 Great Horned Owls, *Bubo virginianus*, during my first 15 years of banding. One of these 15 owls was shot locally, but another was found injured at Bluffton, Minnesota, 730 km to the southeast, an unusual distance for a supposed year-round resident to travel.

A review of the literature then disclosed that the farthest reported movement of this species was by an individual banded at Muscow, Saskatchewan, by John R. Carter, and shot over 160 km to the southeast (Lincoln 1939). Further evidence for a south or southeasterly movement could be inferred from careful subspecific determinations of Great Horned Owl specimens from Nebraska and the Dakotas (Swenk 1937). Swenk's studies indicated that many of the owls shot in fall and winter in Nebraska and the Dakotas must have originated from Canada. My interest was aroused, and an extensive banding program commenced.

Methods

My efforts were first aided by 15-year-old Bill Horseman, who located 5 nests near Saltcoats in 1958 and 23 nests in 1959. In 1960, I had a weekly birdwatching program on the Yorkton television station, sponsored by the Brooke Bond Company to promote the Peterson bird cards in their tea and coffee. Peterson's *Field Guides* were offered as prizes to the boys finding the most owl nests, and 150 flightless young were banded.

After I moved from Yorkton to Saskatoon, annual requests in Doug Gilroy's nature column in the *Western Producer* resulted in many reports of owl nests from interested farmers, many of whom have continued to locate nests each year. School teachers at Yellow Creek and Crystal Springs interested their pupils in the project.

Nestling owls were banded on evenings and weekends throughout May and occasionally into June, most within a 250-km radius centered 75 km east of Saskatoon. I was assisted by many enthusiastic students who climbed the most difficult trees. We travelled up to 1900 km per weekend, banding as many as 61 nestling Great Horned Owls in 23 nests in 1 day. With visits to 1015 successful nests, 2204 nestlings and another 25 fledglings out of the nest were banded.

Results and Discussion

The reproductive success of these owls through 1975 has been described previously (Houston 1971, 1975).

From the 2229 flightless young banded, there have been 209 recoveries, a rate of 9% to date, projected to reach nearly 10% when all recoveries from these birds have been received. This compares with a recovery rate of 23% on all available North American bandings of 478 nestlings through 1941 (Hickey 1952).

Means of Recovery

The commonest reported reason for recovery was "shot," and the second "caught in trap" (Table 1). Twenty-four of the latter were in pole-traps at a single game farm near Saskatoon, and most of the remaining 17 were in traps set for fur-

TABLE 1—How 209 banded Great Horned Owls were recovered

Owls recovered	Number recovered		
	Banded through 1967	Banded 1968 & after	Total
Shot	34	22	56
In trap	20	21	41
Found dead	12	29	41
Hit by car	4	11	15
Dead on highway	7	7	14
Electrocuted	3	10	13
Skeleton or band only	5	6	11
Injured	3	3	6
Miscellaneous*	4	8	12
Total	92	117	209

*Includes two each caught in building, caught in fence, caught by hand, and hit by train, and one each drowned, caught by dog, caught in Bal-Chatri banding trap, and collected as scientific specimen.

bearing animals such as muskrats. Twenty-nine owls died on highways.

There was a statistically significant decline from 37% to 19% ($P < 0.015$ by chi-square, 1 df) in owls reported shot in the more recent of the two periods (Table 1), perhaps reflecting the gradual public awareness of the increased protection afforded hawks and owls by 1960 legislation in Saskatchewan, and possibly a tendency to report birds shot as being found dead. As highways improved, more owls were hit by cars, and as farms received electricity, more owls were electrocuted, though these increases are too small to show a statistically significant difference.

Mortality and Longevity

As reported by Hickey (1952), band recoveries suggest a high mortality in the first year of life. Almost half of my recoveries (102 of 209) were in the same calendar year as banding, and another 26 occurred in the first 4 months of the following year, for a total of 61% within the first year of life. Subsequent years were calculated as ending each 30 April (Table 2).

Fifteen recoveries were of owls 5 years old or more. The oldest in this series was Number 508-08090, banded in a nest found by Bill Horseman near Bredenbury, Saskatchewan (50°50′N, 102°20′W), on 17 May 1959 and caught in a trap at Roblin, Manitoba (51°20′N, 101°20′W), on 4 December 1972. Hickey (1952) and Kennard (1975) referred to a Great Horned Owl, banded by Emerson A. Stoner in California, recovered 12 years and 8 months after banding, and Stewart (1969) reported another

TABLE 2—Time of recovery after banding for 209 Great Horned Owls

Year banded	Number banded	Time of recovery in years											
		0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	9–10	13–14	?†	Total
1946–1957	15	1	1	—	—	—	—	—	—	—	—	—	2
*1958	22	3	1	—	—	—	—	—	—	—	—	—	4
*1959	70	4	4	—	1	—	—	1	—	—	1	—	11
*1960	150	7	4	4	1	4	1	—	—	—	—	—	21
1961	35	3	1	—	—	1	—	—	—	—	—	1	6
1964	69	8	—	—	—	—	—	—	1	—	—	—	9
1965	13	3	—	—	—	—	—	—	—	—		—	3
1966	116	8	1	1	—	1	—	—	—	—		—	11
*1967	258	18	1	2	—	—	1	1	1	1		—	25
*1968	402	20	8	3	—	—	2	—	—			—	33
*1969	224	11	6	1	3	—	2	—	1			—	24
*1970	285	11	4	1	1	—	2	—				1	20
1971	135	5	3	—	—	—	—					—	8
1972	168	15	—	—	—	—						—	15
1973	50	1	3	—	—							—	4
1974	65	2	2	—								—	4
1975	145	4	1									—	5
1976	107	4										—	4
Total	2229	128	40	12	6	6	8	2	3	1	1	2	209

†Skeleton found; year of death not known.
*Build-up years (see text).

TABLE 3—Distance of Great Horned Owl recoveries in different months

Month of recovery	Distance (km) — 1st 12 months					Distance (km) — later years				
	0–10	11–40	41–120	121–250	>250	0–10	11–40	41–120	121–250	>250
May	1	—	—	—	—	5	2	3	—	—
June	9	—	—	—	—	1	1	2	1	—
July	8	1	1	—	—	—	1	2	—	—
August	14	—	—	—	—	3	1	2	1	—
September	13	4	—	—	—	2	1	1	1	1
October	12	6	1	—	1	3	4	3	3	
November	2	3	1	—	7	1	1	—	1	3
December	3	2	3	—	5	2	—	3	—	2
Autumn	2	—	1	—	1	—	—	2	—	—
Winter	—	—	1	—	1	—	—	—	—	—
Unknown	1	—	—	—	—	—	—	1	—	1
January	—	1	—	—	3	—	—	2	1	2
February	1	—	2	—	2	—	1	—	1	2
March	3	1	—	—	3	—	2	—	2	1
April	—	1	2	4	1	1	3	2	—	—
Total	69	19	12	4	24	18	17	23	11	12

owl, banded in Iowa on 23 April 1939 and recovered near the banding site on 6 October 1952, 13 years and 5½ months later. The Bredenbury owl at 13 years, 6½ months appears to represent the longest survival of a non-captive owl of this species published to date.

From my data on 207 owls, before receipt of 7- and 9-year-old recoveries banded in 1969 and 1967, Robert S. Adamcik calculated "dynamic" mortality rates as follows: 57.3% in the first year, 44.4% in the second year, and an average of 28.4% annually thereafter. Adamcik's separate calculations for those owls shot or trapped and for those dying by other means, showed no appreciable difference when applied to my results.

Timing of Movements

My recoveries indicate that mortality is highest in the first six months and that fledgling owls are slow to leave the vicinity of their nest site. Of 34 recoveries before the end of August, only two were 11 km or more from the nest site; the most distant was an owl that moved less than 50 km southeasterly along the very highway that its nest was beside. Of the 37 recoveries in September and October, 35 were within 40 km of the nest; the only owl to be recovered beyond 251 km before the end of October was also the only one of the 36 distant fliers to travel in a northeast direction. A major southeasterly incursion, reaching as far as Iowa and Nebraska, then occurred during November and December (Tables 3, 5).

After a single Minnesota recovery at the end of the first April, there were then no recoveries of owls beyond 251 km in any subsequent years between April and August, although recoveries beyond this distance recurred in subsequent fall and winter months (Table 3). Such data suggest that most long-distance dispersals are probably seasonal movements, akin to those made by other birds such as waxwings and goshawks, and that most of these owls return to within 120 km of their origin before breeding.

Direction of Movements

Special attention was paid to those owls that moved more than 251 km, the radius of the main banding area. From the beginning, it was apparent that they followed an unusually consistent southeasterly course, followed to this date by 35 of the 36 owls that travelled this distance (Figure 1, Table 4). This is statistically significant; by direct calculation the possibility of this occurring by chance is 3.4×10^{-21}. Full details of these recoveries are provided in Table 5.

Although the greatest human population densities are to the southeast of the banding area, this can hardly explain the remarkably consistent direction of movement shown on the map. Some equally well populated areas within a 1500-km radius are without representation, and

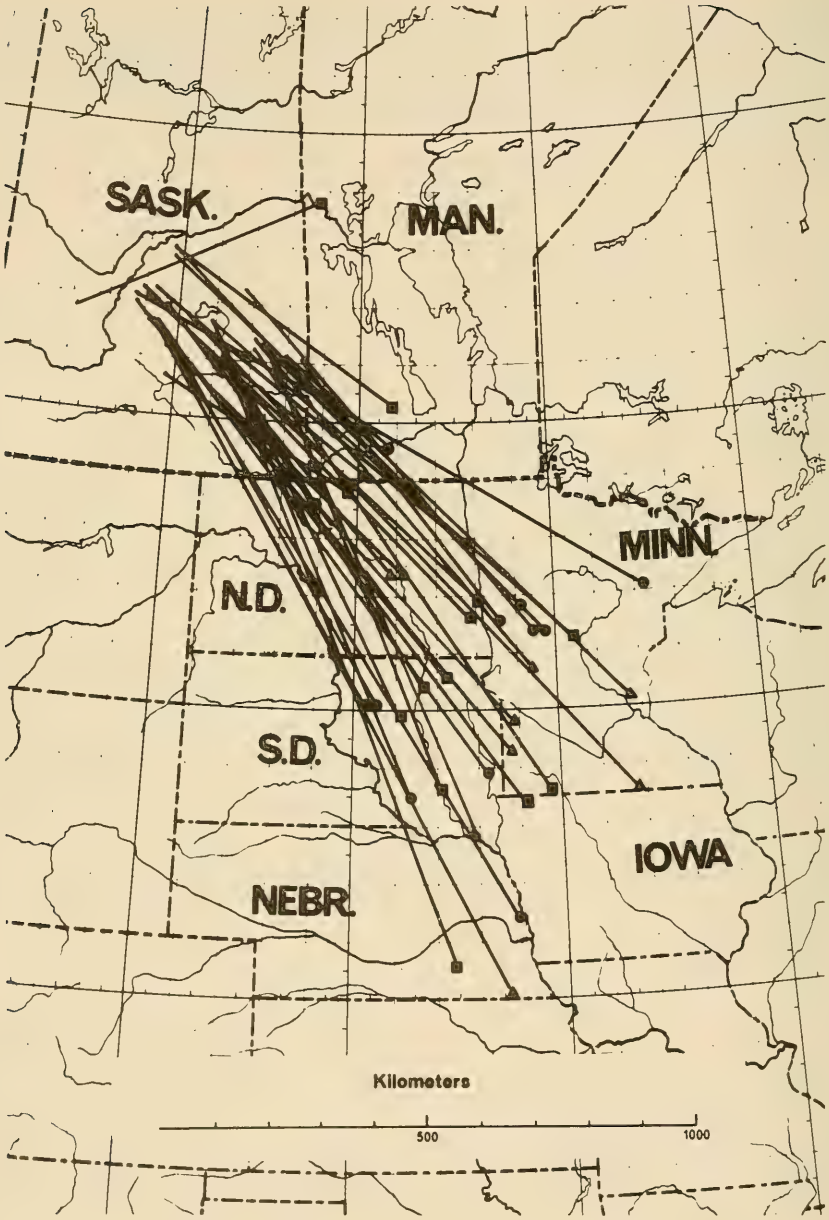

FIGURE 1. Movements of greater than 250 km, by 36 Great Horned Owls. Squares—place of direct recovery in same calendar year as banding (10). Triangles—place of recovery in first four months of succeeding year (14). Circles—place of recovery of owls more than 1 year old (12). Note the consistent direction of travel.

some of the southeasterly recoveries have been from sparsely settled districts. More probably the owls are following the aspen-grove and mixed-forest areas which slope to the southeast, perhaps aided somewhat by prevailing northwesterly winds. It is also the commonest direction to be followed by true migrant species leaving our province.

Shorter movements were more random in direction, though here as well there is a slight

TABLE 4—Direction (by quadrant) and distance travelled by 209 Great Horned Owls

Distance (km)	Direction				
	NE	SE	SW	NW	Total
0–10	—	—	—	—	87
11–40	10	14	5	7	36
41–120	12	10	7	6	35
121–250	3	5	3	4	15
Over 251	1	35	0	0	36
Total	26	64	15	17	209

statistically insignificant trend to move in a southeasterly or northeasterly direction (Table 4).

Relation of Movements to Reproductive Success

During the "build-up years," 1958–59–60 and 1967–68–69–70, shown with asterisks in Table 6, when reproductive success was above average and the population was increasing (Houston 1975), there was a striking decrease in distance travelled as compared to intervening years.

TABLE 5—Long-distance recoveries (>251 km) of Great Horned Owls banded in Saskatchewan

Date and place of banding	Date and place of recovery		Means of recovery	Distance (km) direction
June 5/60 Saltcoats	Nov. 17/61	N of Glenboro, Man.	Shot	265 SE
May 18/70 Kelliher	Nov. 17/71	Glenburn, N.D.	Shot	340 SE
May 20/72 S of Kelliher	Mar. 30/73	Wakopa, Man.	Found dead	340 SE
May 20/61 Bethune	Fall 1961	Willow City, N.D.	Shot	400 SE
May 25/72 N of Rosetown	Oct. 1972	The Pas, Man.	Car	485 ENE
May 13/72 Birch Hills	Nov. 20/72	Gladstone, Man.	In trap	510 SE
May 15/60 MacNutt	Mar. 28/65	Barnesville, Minn.	Shot	610 SE
May 19/75 E of Stalwart	Mar. 19/76	Bordulac, N.D.	Found dead	620 SE
May 14/66 Plunkett	Winter 1967	Carrington, N.D.	In building	660 SE
May 20/72 S of Kelliher	Dec. 8/72	Aberdeen, S.D.	Found dead	725 SSE
May 24/56 W of Yorkton	Dec. 17/57	Bluffton, Minn.	Injured	730 SE
May 21/73 Strasbourg	Sept. 18/74	Seneca, S.D.	Found dead	750 SE
May 10/69 Dana	Jan. 13/73	Grand Forks, N.D.	Shot	750 SE
May 22/66 Oxbow	Nov. 26/66	Little Rock, Iowa	Shot	780 SE
May 20/72 Theodore	Apr. 30/73	Lowry, Minn.	Found dead	795 SE
May 20/72 E of Wynyard	Dec. 8/72	Orient, S.D.	Found dead	820 SSE
May 26/75 W of Meacham	Nov. 17/75	Fargo, N.D.	Found dead	830 SE
May 16/71 S of Young	Nov. 26/71	Hoven, S.D.	Found dead	830 SE
June 4/61 Klogei Lake	Oct. 10/72	Rush Lake, Minn.	Band found	835 SE
May 17/64 Otthon	Dec. 29/64	Ethan, S.D.	Injured	870 SSE
May 24/61 Aberdeen	Nov. 13/61	Sheldon, N.D.	Shot	885 SE
May 20/72 E of Wynyard	Nov. 12/72	Pillager, Minn.	In trap	895 SE
June 6/65 Bradwell	Dec. 5/65	Langford, S.D.	Found dead	915 SE
May 11/69 W of Kinistino	Dec. 23/72	Detroit Lakes, Minn.	Car	925 SE
May 21/72 E of Earl Grey	Feb. 12/73	Ivanhoe, Minn.	Highway	940 SE
May 23/71 E of Wynyard	Feb. 4/73	Douglas Co., S.D.	Found dead	965 SE
June 19/66 Willowbrook	Nov. 26/66	Worthington, Minn.	Band found	980 SE
May 21/67 Willowbrook	Jan. 15/68	Meckling, S.D.	Shot	990 SSE
May 16/71 S of Zelma	Mar. 11/72	St. Leo, Minn.	Highway	1015 SE
May 9/70 E of Young	Feb. 1972	Dell Rapids, S.D.	Found dead	1045 SE
May 3/70 Floral	Jan. 1974	Meadowlands, Minn.	In trap	1080 SE
May 14/66 Yellow Creek	Feb. 4/67	Blaine, Minn.	In trap	1175 SE
May 20/67 Jansen	Jan. 14/68	Glenville, Minn.	Shot	1210 SE
May 30/76 S of Kelliher	Dec. 12/76	Geneva, Nebr.	Injured	1225 SSE
May 19/69 Renown	Nov. 22/70	Irvington, Nebr.	Shot	1280 SE
May 19/69 S of Young	Jan. 5/70	Burchard, Nebr.	In trap	1415 SE

NOTE: Band numbers and latilong block coordinates of places of banding and recovery are availale from the author on request.

TABLE 6—Distance of recoveries of Great Horned Owls in build-up years as compared to all other years

	Distance (km)					
	0–10	10–40	41–120	121–250	>251	Total
Build-up years[1]	57	22	17	3	4	103
Other years[2]	30	14	18	12	32	106
Totals	87	36	35	15	36	209

[1]Build-up years were 1958, 1959, 1960, 1967, 1968, 1969, and 1970.
[2]Includes 39 owls banded in build-up years and recovered in other years; only two owls banded in other years were recovered in build-up years.

During the "build-up years," coincident with increasing numbers of the Snowshoe Hare, *Lepus americanus* (Rusch et al. 1972; McInvaille and Keith 1974), 77% of the owls were recovered within 40 km of the banding site, and only 7% travelled more than 120 km. During other years, only 41% were recovered within 40 km, whereas an equal 41% travelled 121 km or more (Table 6). This difference is highly significant ($P<0.001$, by chi-square test, 2 df).

The correlation of high reproductive success with peaks in the Snowshoe Hare population has been noted (Houston 1971, 1975), but is being correlated more precisely in a companion paper by Adamcik et al. (1978).

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Notes

Food of Ringed Seals and Bowhead Whales near Point Barrow, Alaska

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Lowry, Lloyd F., Kathryn J. Frost, and John J. Burns. 1978. Food of Ringed Seals and Bowhead Whales near Point Borrow, Alaska. Canadian Field-Naturalist 92(1): 67–70.

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Ringed Seals, *Phoca (Pusa) hispida,* and Bowhead Whales, *Balaena mysticetus*, are ecologically important components of the Chukchi-Beaufort marine ecosystem. Ringed Seals are present in the area throughout the year in association with sea ice. Their numbers and spatial distribution vary greatly in relation to seasonal changes in ice cover. Bowhead Whales winter in the Bering Sea and summer in the Beaufort Sea and Amundsen Gulf. They pass close to Point Barrow during their spring and fall migrations. Both species are regularly taken by Eskimo hunters from the settlement of Barrow.

Ringed Seals are presently numerous in this region and are probably at or near the carrying capacity of their habitat. The Bering-Chukchi-Beaufort Sea population of Bowhead Whales was greatly reduced during the late 19th century and the population is still below the level that existed prior to commercial whaling. Ecological relationships between these two marine mammals are unclear. This note indicates that in the vicinity of Point Barrow, Alaska, these two species utilize the same primary prey items and hence some competition for food may exist.

Methods and Materials

Table 1 lists the pertinent information regarding the 16 Ringed Seals and 2 Bowhead Whales from which stomach samples were collected. All animals were taken in the vicinity of Point Barrow (71°23′N, 156°30′W). Samples utilized included the entire contents of stomachs obtained from the seals and small subsamples of stomach contents from the Bowhead Whales.

When possible, each animal was weighed and measured, and the date, time, and location of capture noted. Age determinations for seals were based on examination of claws and/or teeth. All contents of the seal stomachs were gently washed on a 1.0-mm mesh screen and preserved in 10% formalin for later examination. The two subsamples of stomach contents from Bowhead Whales were preserved in 10% formalin.

Laboratory analysis of material involved macroscopic sorting followed by microscopic examination and identification of prey. Food items were identified using appropriate taxonomic keys and from voucher specimens maintained at our laboratory and at the University of Alaska Marine Museum Sorting Center. The volume of each type of food was measured by water displacement. Where possible, numbers and size ranges of prey items consumed were determined.

Results

As no clear time-, sex-, or age-related differences in diet were apparent, the data from all 16 Ringed Seals were pooled. Over three-quarters of the combined total volume of food was euphausiids (*Thysanoessa inermis* and *T. raschii*), which occurred in 11 of 16 stomachs examined. Gammarid amphipods (*Anonyx nugax, Gammaracanthus loricatus, Acanthostepheia behringiensis, Gammarus zaddachi,* and *Atylus* sp.) were also found in 11 stomachs but comprised only 4.6% of the combined total volume. Hyperiid amphipods (*Parathemisto libellula* and *P. abyssorum*) occurred in seven stomachs, always in association with euphausiids, and accounted for 0.3% of the total combined volume. Isopods (*Saduria entomon*) were found in only two stomachs but made up 15.9% of the total combined volume. This high percentage was largely the result of a seal taken on 13 June 1976 the stomach of which contained 200 ml *Saduria.* Shrimp (*Sclerocrangon boreas, Lebbeus polaris,* and *Pandalus* sp.), mysids (*Mysis litoralis* and *Neomysis rayii*), and squid (species unknown) appeared in a few stomachs in small volumes. Fishes were represented almost entirely by otoliths. Otoliths of 30 Polar Cod (*Boreogadus saida*), two Capelin (*Mallotus villosus*), and one Saffron Cod (*Eleginus gracilus*) were identified. Fish remains occurred in five seal stomachs.

TABLE 1—Ringed Seal and Bowhead Whale specimens from which stomach contents were examined

Date of capture	Sex	Weight (kg)	Standard length	Age (yr)	Source of specimen
Seals					
Feb.-Aug. 1975	M	—	86.2 cm	3	ADF&G[1]
Apr.-July 1975*	M	55.5	119.7 cm	10	NARL[2]
Apr.-July 1975*	M	48.2	115.4 cm	11	NARL
Apr.-July 1975*	M	50.9	121.5 cm	17	NARL
Apr.-July 1975*	M	47.3	117.8 cm	10	NARL
Apr.-July 1975*	F	43.2	112.5 cm	13	NARL
Apr.-July 1975*	M	37.7	110.4 cm	4	NARL
Apr.-July 1975*	M	35.0	113.7 cm	6	NARL
Apr.-July 1975*	M	53.6	124.0 cm	18	NARL
3 Sept. 1975	F	11.8	—	pup	ADF&G
11 May 1976	M	49.8	121.5 cm	8	NMFS[3]
25 May 1976	M	—	106.0 cm	6	NMFS[3]
25 May 1976	M	—	97.0 cm	5	NMFS[3]
13 June 1976	M	59.1	125.0 cm	14	ADF&G
7 Aug. 1976	M	40.9	119.1 cm	8	ADF&G
7 Aug. 1976	F	38.6	114.4 cm	11	ADF&G
Whales					
10 Sept. 1976	F	—	16.0 m	—	NMFS[4]
20 Sept. 1976	F	—	14.3 m	—	NMFS[4]

*Exact date of capture unknown but estimated from reproductive state of specimens.
[1] Provided by Alaska Department of Fish and Game personnel.
[2] Provided by Naval Arctic Research Laboratory personnel.
[3] Provided by Robert Everitt, National Marine Fisheries Service.
[4] Provided by J. R. Patee and Robert Everitt, National Marine Fisheries Service.

Subsamples of stomach contents from Bowhead Whales consisted of 17.5 ml from specimen number 76-B-6F and 33.0 ml from number 76-B-7F. Since only subsamples were examined, pooling of data may not be justified. Prey items in the two samples, however, were similar and little error should result from combining them.

Euphausiids (all identifiable material was *Thysanoessa raschii*) made up 90.3% of the total combined volume. Gammarid amphipods (*Gammarus zaddachi, Acanthostepheia behringiensis, Monoculoides zernovi,* and *Rozinante fragilis*) accounted for 6.9%, and the hyperiid amphipod *Parathemisto libellula* made up 2.7%. One sample contained a partial carapace of an unidentifiable shrimp, another contained a small pebble.

Discussion

The primary items found in the stomachs of Ringed Seals taken from different geographical regions indicate marked variation in food consumed. In an examination of 47 Ringed Seal stomachs taken near Baffin Island during August and September, Dunbar (1941) found that the amphipod *Parathemisto* (= *Themisto*) *libellula* was the predominant food. Mysids (*Mysis oculata*) were commonly eaten and other amphipods, euphausiids, and fishes were occasionally consumed. The same general results were reported by McLaren (1958). In the northwestern Bering Sea and the Sea of Okhotsk, euphausiids (*Thysanoessa raschii*) appear to be the chief food item. Shrimps, amphipods and various schooling fishes are sometimes important in the diet (Fedoseev 1965; Fedoseev and Bukhtiyarov 1972; Nikolaev and Skalkin 1975). Kenyon (1962) found shrimp (*Pandalus* sp.) to be the primary food, with fishes, mysids, and gammarid amphipods eaten in small quantities in Bering Strait during May and June. Johnson et al. (1966) in an extensive investigation of the foods of Ringed Seals near Point Hope and Kivalina, Alaska, found fishes (*Boreogadus saida, Eleginus gracilus,* and cottids) to be the main food during November through February. Beginning in March and continuing through June, crustaceans (shrimps, amphipods, crabs, and mysids) made up the bulk of the Ringed Seal's diet at these locations. Results from other localities in the eastern Bering and Chukchi Seas follow the same general pattern (Lowry, Frost and Burns, unpublished data).

It appears that food consumed by Ringed Seals at any given place and time will consist of the most abundant and available suitable species which, in the western Beaufort Sea during late spring and summer, apparently is euphausiids. It is noteworthy that a seal

collected 150 km east of Point Barrow, 35 km offshore on 20 August 1976 (data not included in this report) had also eaten almost entirely euphausiids. In 247 Ringed Seal stomachs containing food, which we have examined from Alaskan waters other than the Beaufort Sea, euphausiids have occurred in only 15. Of those, 11 were taken in the northeastern Chukchi Sea, at Point Hope, in late May 1976.

Bowhead Whales are considered to feed in a skimming mode utilizing their highly specialized baleen plates (Nemoto 1970). They would therefore be expected to feed mostly on copepods and to a lesser extent on euphausiids and other zooplankters. Tomilin (1957) cited indirect evidence indicating that the copepod *Calanus finmarchicus* and the pteropod *Limacina helicina* are major food items. MacGinitie (1955) reported that bowheads (presumably near Barrow) ate euphausiids, mysids, pteropods, and copepods. Mitchell (1975) indicates that in the eastern Arctic, bowheads sometimes eat benthic amphipods as well as mysids and other similar zooplankters.

The results of our very limited sampling of stomach contents from Bowhead Whales agree closely with the statements of Mitchell (1975). Euphausiids are, by far, the most important food item. Hyperiid amphipods, which are apparently associated with swarms of euphausiids, were much less common. The finding of a considerable number of benthic gammarid amphipods indicates that bowheads sometimes forage very near or on the bottom, at least in shallow-water areas. Indications of benthic foraging have been observed and photographed during aerial surveys of bowheads close to shore immediately east of Point Barrow (J. Burns, unpublished observations).

Bowhead Whales migrate apparently in response to seasonal changes in ice conditions. Whales captured at Point Hope and Point Barrow during the northward spring migration in April through June have empty or near-empty stomachs (Johnson et al. 1966; Durham*; Marquette†; G. Seaman, personal communication). Whether bowheads feed on the wintering grounds is not known. Suitable types of foods are available in portions of the Bering Sea, at least during the spring and summer (Nemoto 1957).

Biological processes in the Beaufort Sea are, to a large degree, regulated by the quantity and character of sea ice. Bowhead Whales are the most ice-adapted of mysticete cetaceans and Ringed Seals are the most ice-adapted pinniped occurring in the northern hemisphere. In the northern portion of their range these two species show broad dietary overlap. Ringed Seals are highly euryphagous, and utilize many species of fishes and crustaceans. Bowhead Whales are considerably more stenophagous and depend mostly on swarms of small to medium-sized zooplankton.

The Beaufort Sea experiences extreme year-to-year variation in the extent of summer sea-ice cover. Although sea ice provides a substrate for a special group of algae (Meguro et al. 1966), the primary effect of ice cover is a lowering of overall productivity by drastically decreasing light penetration (Mohr and Tibbs 1963). A decrease in the total primary production of the area would result in lower productivity at higher trophic levels. Stirling et al. (1977) speculate that reduced production caused by the heavy ice conditions of the winter of 1973–1974 may have been responsible for an observed decrease in productivity of Ringed and Bearded Seals. The long-term ecological effect of fluctuations in annual production would be difficult to predict. It seems likely, however, that short-lived stenophagous species would be most rapidly and acutely affected. Specific data on trophic interaction of major components of the arctic ecosystem are urgently needed as potentially drastic long-term environmental modifications such as offshore oil drilling are imminent.

Bowhead Whales, which are currently reduced in numbers and "officially" considered as a rare and endangered species, were once abundant in arctic waters. Scheffer (1976) indicates that the pre-exploitation population level was composed of about 10 000 animals and estimated the present population to be about 2000. No long-term data are available for Ringed Seal numbers. An estimate of the early spring population of Ringed Seals in the area where bowheads summer (Beaufort Sea and Amundsen Gulf) is at least 30 000 animals (Burns and Harbo 1972; Stirling et al. 1977). This number increases greatly during the summer, with the seasonal influx of seals from the south. Two interesting questions arise. As the bowhead population declined, did populations of other marine mammals or birds increase because of increased abundance of food? Will Bowhead Whales be able to regain their former population levels and, if so, will it be at the expense of other species? Unfortunately, no data exist to answer the first question and too little information is presently available adequately to answer the second.

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specimens, and acknowledge project support provided by the U.S. Bureau of Land Management Outer Continental Shelf Environmental Assessment Program and Federal Aid in Wildlife Restoration Project W-17-9.

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Birds and Mammals as Passive Transporters for Algae Found in Lichens

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Although algae are found world-wide, little is known about how their distribution is achieved. An understanding of algal dispersal may in turn be important to understanding lichen distribution. Known mechanisms of algal dispersal include wind dissemination (Proctor 1959) or transport on the external parts of birds (Proctor 1959) and insects (Maguire 1959). Opinions vary as to the success with which algal symbionts (phycobionts) and fungal symbionts (mycobionts) unite in lichen formation. This study attempted to determine whether birds and mammals could serve as transporting agents for phycobionts.

White-throated Sparrows (*Zonotrichia albicollis*), Black-capped Chickadees (*Parus atricapillus*), and House Sparrows (*Passer domesticus*) were mist-netted from two separate areas. One area was located in Branford, Connecticut in a hardwood-hemlock forest, and the other area was a wooded residential area in Bethany, Connecticut. White-footed Mice

(*Peromyscus leucopus*) and Red Squirrels (*Tamiasciurus hudsonicus*) were live-trapped from the first area.

The birds and mammals were "washed" (feet, bills, and tails) with distilled water from a squeeze-bottle to remove any particulate matter. The wash water was drained into sterile dilution bottles in the field and later (within 24 h) transferred into 100-ml soil-water culture bottles. The soil-water bottles had been prepared by combining 0.65 to 1.5 cm soil (sieved by a #10 U.S. Standard Sieve) with 0.001 g $CaC0_3$ (to neutralize soil acidity) and enough distilled water to bring the total volume to 75 ml. They were then autoclaved three times at 135°C allowing a 24-h interval between autoclavings. The soil-water bottles were then individually inoculated with the full amount of wash water from each specimen. The inoculated soil-water bottles were then placed in a culture cabinet, under continuous light at 24°C. After 15 days, random samples from the culture bottles were examined microscopically.

Most of the cultures (from both birds and mammals) contained algal growth. Some of the algae included genera found as lichen phycobionts, *Protococcus, Nostoc, Coccomyxa, Anabaena, Chlorococcum,* and *Trentepohlia.* One mammal culture contained *Trebouxia,* which is rarely found outside of lichen thalli (Ahmadjian 1967). Other algae cultured, which are commonly found in terrestrial, aquatic, and arboreal environments, were *Ulothrix, Chlorella,* and *Microspora.*

Clearly, both birds and mammals act as passive transporters for viable forms of algae. Therefore, they may well be dispersal agents for phycobionts.

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Winter Predation by Black-capped Chickadees and Downy Woodpeckers on Inhabitants of the Goldenrod Ball Gall

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Schlichter, Lyanne. 1978. Winter predation by Black-capped Chickadees and Downy Woodpeckers on inhabitants of the Goldenrod Ball Gall. Canadian Field-Naturalist 92(1): 71–74.

The goldenrod ball gall larva, *Eurosta solidaginis,* appears to be a commonly exploited winter food source for the Downy Woodpecker, *Picoides pubescens,* and the Black-capped Chickadee, *Parus atricapillus.* Downies fed most heavily at the forest edge, whereas chickadees used both the forest edge and the open field. Misshapen galls were untouched, their rejection apparently based on visual cues. By the end of winter most normal appearing galls were superficially scored, even if not opened. Although many of these scored galls had their larvae preyed upon, some were rejected without penetration. Rejected galls usually contained dead mature fly larvae or mordellid beetle larvae.

Key Words: Downy Woodpecker, Black-capped Chickadee, goldenrod gall, prey selection.

During the winter months, many naturalists have seen Downy Woodpeckers *(Picoides pubescens)* and Black-capped Chickadees *(Parus atricapillus)* on stems of goldenrod, pecking at large round galls and extracting the inhabitants. Ping (1915) reports that these galls are produced on Canada goldenrod *(Solidago canadensis)* by the gall fly *Eurosta solidaginis* (Diptera, Tephritidae). In examining large numbers of these galls I identified three types of attack: small clean holes and large irregular holes, both reaching into the center of the galls, and superficial scoring. Other galls were apparently untouched. This food source has not been mentioned in surveys of bird feeding habits (e.g., Martin et al. 1961). Use of the resource and reasons for differences in the type of attack are examined in this study.

Gall Structure

An adult female gall fly deposits an egg on a goldenrod stem in the spring. By early summer the larva emerges and burrows into the stem, initiating gall formation (Ping 1915). Stems are occasionally found on which two or three eggs have been laid, each

producing a gall. It is unknown whether the same female is responsible for all larvae on a single stem. Proliferation of plant tissue yields an eccentric ball-shaped gall though misshapen galls are not uncommon. In mature galls, a tunnel stretches from the core to one edge, terminating just beneath the surface. Normal galls that have not been preyed upon contain a white larva near the tunnel's outer edge. Three types of abnormalities are recorded in this study:

(1) Gall larvae that have died early in the season or are unusually small occupy small misshapen galls.

(2) Occasionally dead mature larvae are found. Mould is usually present in the tunnels of such larvae.

(3) In addition to the gall-forming larva, a small elongate larva of the beetle *Mordellistena unicolor* (Coleoptera, Mordellidae) is sometimes found in a separate tunnel (Ping 1915). This second tunnel usually lies on the periphery of the fly larva's tunnel, at the top of the gall. I never found the two insect species in physical contact and, in the presence of the beetle the gall fly larva appeared well developed and healthy. The relationship between these two larvae has not been investigated.

Study Sites

One study site was located on a low-lying road allowance near Kleinburg, Ontario. It was bounded by the junction of two roads, a stream, and a secondary-succession forest. At the forest edge grew dense clumps of goldenrod, an occasional blackberry (*Rubus* sp.) and a few red-osier dogwood (*Cornus stolonifera).* Close to the road junction there was a fairly uniform stand of goldenrod with little else visible above the snow.

At the end of the winter a second site was examined on the flood plain of the Thames River near London, Ontario. This site was bordered by open fields on three sides and a secondary-succession forest on the fourth. The nearest road was several hundred yards away.

Methods

At the Kleinburg site predation was monitored from late November until late February. Two quadrats, 10 × 10 m, were laid out at the forest edge and another two in the open field as far as possible from trees. At each visit I collected from each quadrat galls that had been penetrated since the last visit. Type of attack and proximity to the forest were recorded.

Comparisons of the degree of predation at the forest edge and in the open field were made using data from both Kleinburg and London. At the London site one quadrat, 30 × 30 m, was laid out at the forest edge and a second in the open field at least 130 m from the nearest tree. At the end of the winter I counted the number of successful attacks by each species on all quadrats.

Predator treatments of normal and abnormal prey were studied at both sites. A large sample (335) of apparently normal galls was collected. Ninety-four small misshapen galls were also collected. These galls were dissected and examined with a 20× hand lens. Type of attack and the presence of fly and beetle larvae were noted.

In all cases deep narrow holes from 1.2 cm to 1.5 cm deep were assumed to be made by the forceps-like Downy Woodpecker bill. Large, irregular holes were attributed to Black-capped Chickadees. I found no report of any other short-billed bird attacking these galls. Since naturalists report that both species sometimes tap galls lightly and abandon further attack. I assume that both birds are responsible for scoring.

Results

Temporal Study

At the forest edge a decline in predation rate by both species was seen after the third week of December (Figure 1). By this time 80.5% of available galls had been successfully attacked at the forest edge.

In the open field downies and chickadees showed a reduced predation rate by the end of January when 60% of available galls had been preyed upon by the two species of birds.

The lack of predation by the end of January was not due to the birds' disappearance from the site. I observed several chickadees and one or two downies on the site at each visit during January and February.

Foraging-site Preference

By the end of the winter downies had preyed upon 39 galls in all three open-field quadrats and 101 in the three forest-edge quadrats. Black-capped Chickadees took larvae from 100 galls in the open field and 91 at the forest edge.

Abnormal Prey

Of the 335 externally normal galls, 149 were found to have internal abnormalities. Only 24.8% of these abnormal galls were successfully attacked, compared with 73.1% of fully normal galls. Forty-nine of the 149 abnormal galls contained one or more mordellid beetle larvae in addition to the fly larva. Of these, only 24.5% had their gall fly larvae removed. None of the mordellid beetle larvae were taken by the birds.

Of the 94 small misshapen galls containing dead, immature fly larvae, only 13.8% were preyed upon. The remaining 81 misshapen galls showed no scoring or any other sign of having been touched by birds. Table I summarizes our findings.

Since the beginning of this study, I have noted similar predation patterns in other southern Ontario sites. Observations have been made in Elgin, Halton, Essex, and Bruce Counties and near Midland, King City and Toronto.

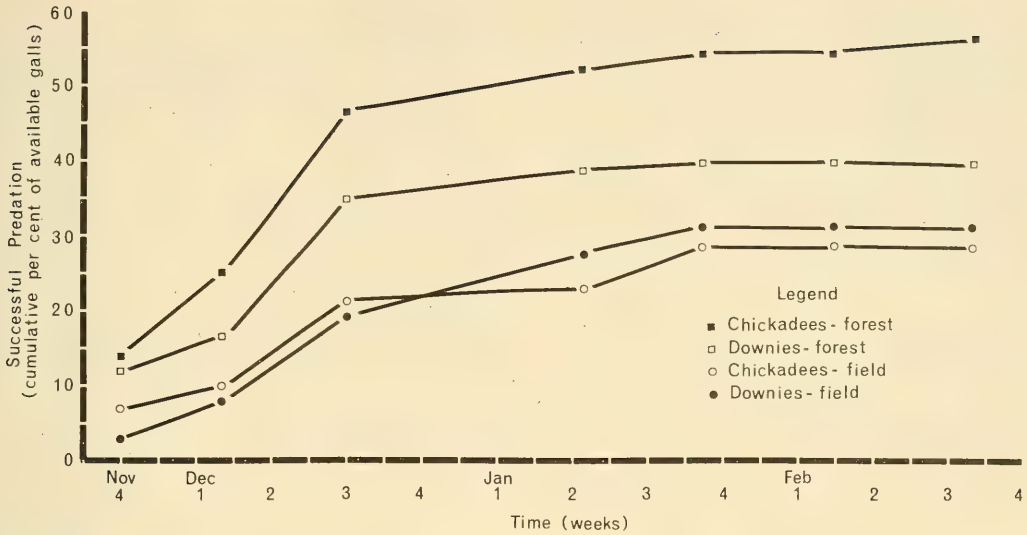

FIGURE 1. Comparison of degree of predation over winter in the open-field and forest-edge habitats at the Kleinburg site. Cumulative scores for successful predation are expressed as the percent of galls originally present on the quadrats.

Discussion

In the temporal study at Kleinburg, the decline in predation rate at the forest edge after the third week of December probably reflects a dwindling resource. By this time 80.5% of available gall larvae were eaten. The birds may have had difficulty in finding the remaining intact galls. This explanation is not as convincing in the open field where only 60% of available fly larvae had been taken.

At the London site, open-field and forest-edge quadrats were separated by more than 100 m. By the end of winter fewer than 50% of the galls present in either quadrat had been preyed upon. In this case downies took more gall larvae at the forest edge than did chickadees. In the open field chickadees took many more larvae than did downies. When data from all quadrats are taken together downies attacked more than 2.5 times as many galls at the forest edge as in the open field. Chickadees, however, took almost equal numbers from the two habitats. This suggests a foraging-site preference that was not apparent at the heavily used Kleinburg site. Such site preferences have been reported in the literature. Odum (1941) found that Black-capped Chickadees often venture far into open fields on feeding forays. Downies seem to prefer the forest edge (Lawrence 1967). It may be that lack of food at the forest edge forced downies to feed in the open field at Kleinburg.

TABLE 1—Comparison of successful predation by Black-capped Chickadees and Downy Woodpeckers on normal and abnormal galls

Type of gall	Number of galls with fly larvae	
	Eaten	Uneaten
Normal	136 (73.1%)	50
Misshapen	13 (13.8%)	81
Externally normal but with internal abnormalities	37 (24.8%)	112
With beetle larvae (included also in third line)	12 (24.5%)	37

It is intriguing that abnormal larvae were rejected, even in late winter when the supply of normal larvae had dwindled. How do the birds make a distinction between galls containing normal and abnormal larvae? For grossly misshapen galls usually containing dead decomposing larvae it is quite possible that rejection is based on visual cues alone. Signs of physical attack were almost always missing.

Use of such obvious visual cues cannot explain rejection of prey in normal-shaped galls. Some naturalists maintain that these birds tap galls, listening for the hollow ring of an already preyed-upon gall. It is possible that the scoring produced by this tapping provides information on the internal condition of occupied normal-shaped galls. Alterations in gall tissue accompanying unhealthy larvae have been found for another goldenrod gall maker (Beck 1954). Alternatively, either the gall fly larvae or the mordellid beetle larvae may themselves produce cues that the

birds can detect. It is likely that the mordellid beetle larvae are unpalatable since none of them were eaten.

Rejection of dead or extremely small larvae with low nutritive value may be an energy-conserving behavior. This does not explain the rejection of the third type of abnormal galls. In this type the presence of the mordellid beetle larva seemed not to harm the gall fly larva, but rather to protect it from avian predation. Further investigation of the "mutualistic" relationship between these two insect species is necessary.

Acknowledgments

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The Status of *Lythrum alatum* (Lythraceae) in Canada

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There are two species of *Lythrum* in Canada. The Purple Loosestrife, *Lythrum salicaria*, a species introduced from Europe, is a familiar weedy plant in wet meadows and along streams through large parts of southern Canada. Boivin (1966) reported this species as occurring in all the Canadian provinces but Saskatchewan, and it is now known from that province on the basis of a recent collection from near Sutherland (*V. L. Harms 18460* (DAO, SASK)). In Ontario, many acres of marshes and low wet ground are resplendent in purple during the height of the flowering season of this plant.

Lythrum alatum, a less showy purple-flowered plant, is a native prairie species, which is widespread throughout the United States, but in Canada is known only from Ontario and British Columbia although Fernald (1950) gave the habitat and range as "Swamps, meadows, prairies and ditches, Ont. and n. N.Y. to B.C., s. to Ga., La. and Tex.; adv. in N.E., N.J. etc." It was first reported as occurring in Canada from the area adjacent to the Detroit River in Essex County, Ontario, and from Point Edward in Lambton County, Ontario, by John Macoun (1883–1886). Numerous collections have been made from Lambton, Kent, and Essex Counties in the area adjacent to the St. Clair River, Lake St. Clair, and the Detroit River since that time. *Lythrum alatum* is certainly of native origin there.

Localities in other parts of Ontario are widely separated as demonstrated in Figure 1. With the exception of the Elgin County record (Stewart and James 1969), the occurrence of *L. alatum* at a distance from the St. Clair River–Lake St. Clair–Detroit River area has not previously been reported. It is now known from additional localities in the following counties (years of collection are given in parentheses): Carleton (1952 and 1969), Durham (1898 or 1889, 1948 and 1952), Elgin (1899, 1968), Essex (1892 and 1974), Haldimand (1915), Kent (1934, 1948, 1960, 1962), Lambton (inland collections 1906 and 1947), Middlesex (1937), and Norfolk (1961).

The localities north of Lake Erie, though widely separated, may represent a native distribution, although the dates of collection might indicate that it was adventive at some of the localities. The collections from Durham and Carleton Counties are considerably disjunct from the main range, and may be introductions, as Fernald (1950) suggested for the

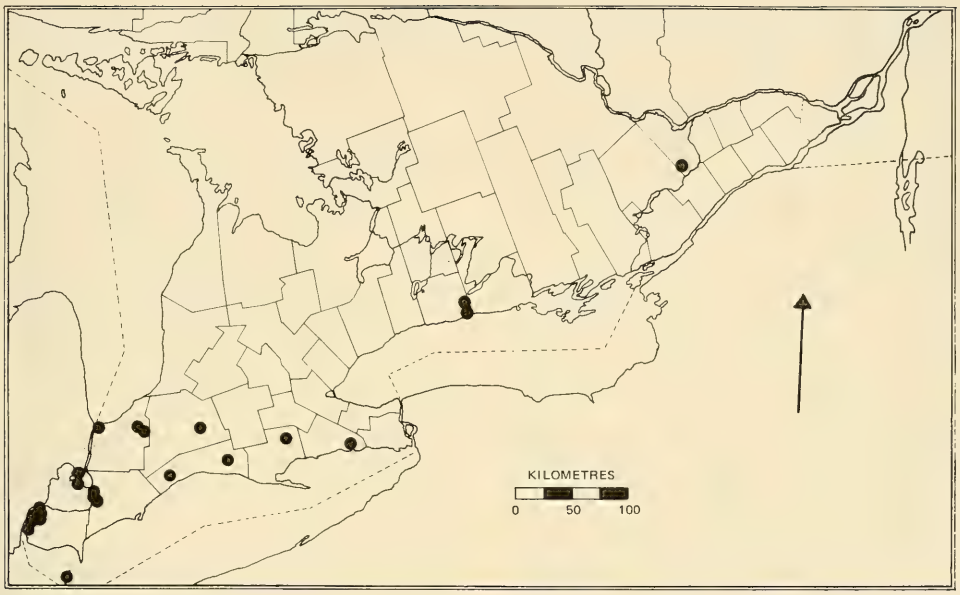

FIGURE 1. The Ontario distribution of *Lythrum alatum* as known from the following herbaria: CAN, DAO, OAC, QK, TRT, and UWO.

New England States, but the early date of 1898 (or 1889) would indicate that it was probably of native origin. The Carleton County localities are in the midst of the Ottawa-Carleton Regional Forest. The Prairie White Fringed Orchid *(Habenaria leucophaea),* a species centered about the lower Great Lakes, has only recently been reported here and was formerly known from near Port Hope in Durham County (Reddoch 1977). This occurrence of a native plant with disjunct distribution similar to that of *L. alatum* supports the possibility that *L. alatum* is also native in both Carleton and Durham Counties.

Lafontaine and White (1974) reported *L. alatum* from Shirleys Bay on the Ottawa River near Ottawa, presumably on the basis of a sight record, but this was later discounted (White 1977) because no voucher specimen could be found, and a detailed search in the field failed to turn it up.

The report from British Columbia (Fernald 1950; Henry 1915; Macoun 1895) is based on a collection from Griffin Lake in the Kamloops District (*John Macoun s.n.,* 6 July 1889, CAN). J. M. Macoun (1895) commented "It is possible that the seeds of the Griffin Lake plants were in some way introduced, though this is not probable." *Lythrum alatum* has not been collected in British Columbia since 1889. The British Columbia collection is disjunct from sites in the western United States.

The native *L. alatum* may be readily distinguished from *L. salicaria* by its linear-lanceolate to oblong-ovate rather than lanceolate leaves; single smaller flowers in the axils of small usually alternate leaves, rather than densely cymose in the axils of whorled or opposite leaves; the glabrous narrowly oblong rather than more or less pubescent somewhat thickened-urceolate calyx; and the wing-margined angles of the upper branches and calyx.

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Prey Utilized by Merlins Nesting in Shortgrass Prairies of Southern Alberta

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During the summers of 1969–1974 field investigations of Richardson's Merlin (*Falco columbarius richardsonii*) were conducted in southern Alberta (Hodson 1976). All Merlins discussed here were nesting in small clumps of poplar (*Populus* sp.) and/or Manitoba maple (*Acer negundo*) adjacent to shortgrass (*Stipa-Agropyron*) prairie. Two abundant passerine birds of this habitat, Horned Larks (*Eremophila alpestris*) and Chestnut-collared Longspurs (*Calcarius ornatus*) together formed 87% of prey during the nesting season.

During field investigations a collection was made of 2070 feathers (primary, secondary, and tail only), legs, and beaks of birds and skulls of rodents, and items were later identified. Although the numbers of individuals of each species could not be determined, the numbers of prey-remain items were high (i.e., many times the maximum from a single prey), and it is assumed that frequency of prey items is representative of comparative numbers of prey captured.

I found that 50% of prey-remain items were from Horned Lark, 37% from Chestnut-collared Longspur, 3% from Western Meadowlarks (*Sturnus neglecta*), 2% from Vesper Sparrows (*Pooecetes gramineus*), and 8% from species of less than 1% of total prey items (Table 1). Some species, such as Pine Siskins, are nonresident on the study area and were undoubtedly picked up during spring migration. A family of newly fledged Merlins was observed pursuing and eating grasshoppers after a heavy hatch of these insects (D. O'Dell, personal communication). In a similar study of Merlins in southern Saskatchewan, Fox (1964) found that the composition of prey remains was 53.5% Horned Larks, 13.6% Chestnut-collared Longspurs, 13.3% Brown-headed Cowbirds (*Molothrus ater*), and 20.1% native sparrows. Chestnut-collared Longspurs are basically birds of grasslands (Table 2) and the smaller amount of this species in prey remains from Merlins nesting in Saskatchewan could be explained by the small amounts of grassland left there. During the time of Fox's study in the early 1960s, 48% (range 28 to 89%) of the territory around 15 Merlin nesting sites was under cultivation; in comparison, only 22% (range 0 to 49%) of territory around 40 Merlin nesting sites I studied in southern Alberta in the early 1970s was under cultivation (Hodson 1976).

In a fescue (*Festuca*) grassland in southern Alberta, Owens and Myres (1973) showed that breeding populations of passerine birds are more dense on grassland than on cultivated land (Table 2). My study area, though primarily *Stipa-Agropyron* prairie, was within a few miles of Owens', and populations of passerine birds were comparable both in density and species. My observations indicated that Merlins were hunting primarily over grasslands.

Grasslands in my study area were mostly grazed (probably > 75%) but did include some mowed and undisturbed grasslands at some time of the year; most undisturbed grasslands in May–July were mown by the end of August. Species of grassland birds taken by Merlins would suggest that they are seldom utilizing undisturbed grasslands; Baird's Sparrow (*Ammodramus bairdii*) and Sprague's Pipit (*Anthus spragueii*), the two most common passerines in undis-

TABLE 1—Prey of Richardson's Merlins in southern Alberta, 1969–1974, as determined by examination of 2070 prey-remain items found at 46 nest sites

Prey item	Prey present, % of nests	Frequency %
Horned Lark (*Eremophila alpestris*)	100	50
Chestnut-collared Longspur (*Calcarius ornatus*)	100	37
Western Meadowlark (*Sturnella neglecta*)	< 10	3
Vesper Sparrow (*Pooecetes gramineus*)	< 10	2
Other species (4% unidentified passerines)[a]		8

[a]Trace species (less than 1%) include McCown's Longspur (*Calcarius mccownii*), Lark Bunting (*Calamospiza melanocorys*), Pine Siskin (*Spinus pinus*), Cedar Waxwing (*Bombycilla cedrorum*), Eastern Kingbird (*Tyrannus tyrannus*), Wilson's Phalarope (*Steganopus tricolor*), Spotted Sandpiper (*Actitis macularia*), unidentified shorebirds (Charadriiformes), Richardson's ground squirrel (juvenile) (*Spermophilus richardsoni*), other rodents (Cricetidae).

TABLE 2—Mean number of passerine pairs per 40 acres (16.4 ha) by land-use type (data from Owens and Myres 1973)

Bird species	Land-use type				
	Fescue grassland			Cultivated land	
	Undisturbed	Mowed	Grazed	Seeded	Fallow
Baird's Sparrow (*Ammodramus bairdii*)	6.75	0.00	0.00	0.00	0.00
Sprague's Pipit (*Anthus spragueii*)	9.50	5.00	0.00	0.00	0.00
Savannah Sparrow (*Passerculus sandwichensis*)	3.75	1.00	1.00	0.00	0.00
Western Meadowlark (*Sturnella neglecta*)	1.00	0.00	1.00	0.00	0.00
Chestnut-collared Longspur (*Calcarius ornatus*)	0.00	10.00	5.50	0.00	0.00
Clay-colored Sparrow (*Spizella pallida*)	0.75	0.00	1.00	0.00	0.00
Horned Lark (*Eremophila alpestris*)	0.00	0.00	2.50	2.00	3.00
Vesper Sparrow (*Pooecetes gramineus*)	0.00	0.00	0.00	0.50	0.00
Red-eyed Vireo (*Vireo olivaceus*)	0.00	0.50	0.00	0.00	0.00

turbed grasslands (Table 2), were not found at all in remains collected at Merlin nest sites. Undisturbed grasslands probably provided better escape cover for potential prey and thus were less productive for hunting Merlins.

In a study of grassland bird communities in the Pawnee IBP Grassland Study Area in Montana, Wiens (1973) states " . . . the response of individual species to grazing effects was more clear-cut. Horned Lark density was greater in grazed plots and, at Pawnee, in plots subjected to heavy summer grazing . . .". The high percentage of Horned Larks found in the diet of Merlins seems to indicate the preference of Merlins for grazed land to hunt over. Owens (1973) found Horned Lark density high on grazed lands but insignificant on other grasslands, and higher only on fallow cultivated lands. Land under cultivation formed a significant portion of territory available for hunting Merlins (22% Hodson 1976), and, although never observed, Merlins undoubtedly utilized these areas as well.

Heavy utilization of Horned Larks and Chestnut-collared Longspurs by Merlins may also be related to the behavior of these birds. Cody (1968) in his work on the Pawnee IBP Grassland Study Area devised a scale of feeding behavior for 14 North American species, and a graph depicting the distance moved over a given time span showed that the two most "active" species were Horned Larks and Chestnut-collared Longspurs. Perhaps the more active feeding behavior of these birds makes them more noticeable to hunting Merlins. Owens (personal communication) has made the additional point that the height of aerial flight displays of some species of grassland birds may make them less available than other species by placing them out of the optimum altitude of hunting Merlins. Owens gives the heights of display of four species under consideration as these: Sprague's Pipit at 300 m, Baird's Sparrow at ground level, Horned Larks at 60 m, and Chestnut-collared Longspurs at 6 m. This mechanism would obviously operate only during breeding display periods of the particular grassland bird.

In summary, I suggest that Merlins of southern Alberta living in shortgrass prairies are probably hunting mainly over grazed grassland where there is little escape cover for potential prey. Although less abundant on my study area, mowed grasslands or agricultural land in seed or fallow would fall in the same category. This is supported by the fact that Horned Larks and Chestnut-collared Longspurs, which were the most heavily utilized prey and were found in remain items at every nest site, are a very common passerine in these habitats and are not common elsewhere. The most abundant species of undisturbed grasslands were not utilized at all. Behavioral attributes of Horned Larks and Chestnut-collared Longspurs may also add to their preference as prey by Merlins.

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Northern Leopard Frogs and Bullfrogs on Vancouver Island

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Green, David M. 1978. Northern Leopard Frogs and Bullfrogs on Vancouver Island. Canadian Field-Naturalist 92(1): 78–79.

Established feral populations of Northern Leopard Frogs, *Rana pipiens,* and Bullfrogs, *R. catesbeiana,* were found in the Parksville area of central Vancouver Island in the summer of 1976. According to C. Darkis of Qualicum Beach, British Columbia and C. Randall of Errington, British Columbia, these frogs were introduced to the drainage region of French Creek in the 1930s as stock for a frog farm, and subsequently released. The source(s) of these stocks is not known. These are the first known occurrences of these species on Vancouver Island; they are not noted as occurring there in any previous literature (Stebbins 1954, 1966; Logier and Toner 1961; Carl 1966; Dumas 1966; Conant 1975).

The dates and numbers of frogs seen in 1976 and 1977 are listed in Table 1. Both adults and larvae of *R. pipiens* were seen on six occasions at Hamilton Swamp, a permanent beaver pond located 1.5 km northwest of Coombs, British Columbia and draining into French Creek. Transforming individuals were seen in late July. Four specimens (DMG 169–172), now preserved, were taken in August 1977.

These frogs were identified as *Rana pipiens,* distinct from other members of the *R. pipiens* complex of species by the straight dorsolateral folds and lack of a distinct tympanal spot (Figure 1) as described by Pace (1974). In *R. pipiens* the dorsolateral folds are continuous and not displaced and, although some specimens show a slight constriction of the fold near the base, they are never broken nor displaced medially towards their posterior as in *R. blairi* and *R. berlanderi.* The distinct white spot on the tympanum seen in *R. utricularia* and most *R. blairi* (Mecham et al. 1973) is absent in *R. pipiens.* This identification was corroborated by F. W. Schueler of the University of Toronto and J. P. Bogart of the University of Guelph. As no adult males were collected and no calls were heard, the shape of the vocal sacs, presence of vestigial oviducts, and mating call characteristics in these frogs could not be checked.

In 1976, *R. catesbeiana* was observed at Dudley Swamp and in large numbers at Bell Lake (Table 1), two extensive beaver ponds near the village of Errington, British Columbia. Six adults were counted

TABLE 1—Sightings of frogs in the Parksville region of Vancouver Island in 1976 and 1977. Numbers of individuals observed are in brackets

Locality	*Rana pipiens*	*Rana catesbeiana*	*Rana aurora*
Hamilton Swamp	6 June 1976 (3) 17 June 1976 (1) 26 June 1976 (4) 29 July 1976 (2)*** 12 Aug. 1976 (3) 21 Apr. 1977 (2)** 19 Aug. 1977 (4)	6 June 1976* 20 Apr. 1977 (1)** 19 Aug. 1977*	6 June 1976 (5) 10 June 1976 (2) 23 July 1976 (1)*** 29 July 1976 (4)*** 12 Aug. 1976 (2) 23 Aug. 1976 (2) 19 Aug. 1977 (2)
Bell Lake		16 July 1976 (100+) 18 July 1976 (100+)	16 July 1977 (1)
Dudley Swamp		21 Aug. 1976 (1)*	
M. Wolfe's Farm		21 Aug. 1976 (6)	
Little Qualicum Falls Provincial Park			1 Aug. 1976 (7)
Englishman River Falls Provincial Park			5 July 1976 (15) 19 Aug. 1977 (3)

* Calls heard.
** Collected by F. W. Schueler.
*** Transforming individuals noted.

FIGURE 1. Immature female Northern Leopard Frog, *Rana pipiens,* (DMG 170) collected 19 August 1977 at Hamilton Swamp on Vancouver Island.

in a small muddy pond at M. Wolfe's farm, Swayne Road, Errington. Calls only were heard at Hamilton Swamp in June 1976 and in August 1977.

F. W. Schueler also collected road-killed specimens of *R. pipiens* (FWS 7711) and *R. catesbeiana* (FWS 7709) near Hamilton Swamp, in April 1977. These are included in Table 1.

These Bullfrog and Northern Leopard Frog populations are far removed from any known previously. They are isolated on Vancouver Island, separated from the mainland by the Strait of Georgia. The nearest previous record of *R. pipiens* to Hamilton Swamp is at Osoyoos Lake in the Okanagan Valley (Carl 1949), roughly 400 km east. The nearest Bullfrogs are those introduced, and now common, across the strait in the lower Fraser Valley near Vancouver. With the Green Frog, *R. clamitans,* found at Victoria (Carl 1966), there are now three introduced species of *Rana* recorded on Vancouver Island.

It would be interesting to know in more detail how the two introduced species, *R. pipens* and *R. catesbeiana,* interact with the native Red-legged Frog, *R. aurora.* Although no detailed study was undertaken, *R. aurora* was seen in numbers about equal to those of *R. pipiens* at Hamilton Swamp (Table 1). At Bell Lake, however, with its substantial numbers of Bullfrogs, only one Red-legged Frog was seen. This may indicate that *R. aurora* and *R. pipiens* can coexist at Hamilton Swamp while being excluded from Bell Lake by *R. catesbeiana.* Comparable situations could be in the elimination of *R. aurora* and *R. boylii* from the San Joaquin Valley in California by introduced Bullfrogs as discussed by Moyle (1973) or the competitive exclusion of *R. pretiosa* by *R. pipiens* in Oregon as discussed by Dumas (1964). The threat of elimination of *R. aurora* from central Vancouver Island by Northern Leopard Frogs and Bullfrogs is probably not severe, however. I have observed Red-legged Frogs to be quite common along forest streams in nearby areas such as Englishman River Falls Provincial Park and Little Qualicum Falls Provincial Park (Table 1). There is an abundance of such forest habitat for the Red-legged Frogs that is unsuitable for colonization by the other two species.

Photographs taken in 1976 and those specimens collected by F. W. Schueler are at the National Museum of Natural Sciences. The four specimens collected 19 August 1977 are in the author's possession.

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Northern Fulmar Breeding Range Extended to Baccalieu Island, Newfoundland

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Montevecchi, W. A., E. Blundon, G. Coombes, J. Porter, and P. Rice. 1978. Northern Fulmar breeding range extended to Baccalieu Island, Newfoundland. Canadian Field-Naturalist 92(1): 80–82.

The numbers of Northern Fulmars (*Fulmarus glacialis*) have been increasing in the boreal regions of the Northeast Atlantic for more than two centuries, and though population growth appears to have slowed recently (Fisher 1952, 1966; Salomonsen 1965) the breeding range of the species continues to expand. In the past few years Northern Fulmars have been found breeding in two locations off Newfoundland: Great Island (47°11′N, 52°49′W) in Witless Bay (Nettleship and Montgomerie 1974) and Funk Island (49°46′N, 54°12′W), as documented in Nettleship's recent (1976) film, "The Funks."

During visits by land and boat on 27 May, 1 and 11 June 1977, to the cliffs just south of Jackson's Gulch on the northeast end of Baccalieu Island (48°07′N, 54°12′W) we sighted five single, light-phased fulmars sitting on ledges (Figure 1); two sites that we could see from the cliff top each had an egg. On 10 August a chick, judged to be 3–4 weeks posthatch, was found; the other site where the egg had been within our reach was empty. Some evidence suggested that predation or predatory disturbance may have been involved. A decapitated, eviscerated adult Northern Fulmar was found nearby on 11 June, and there were signs of Red Fox (*Vulpes vulpes*) activity (digging at Leach's Storm-Petrel (*Oceanodroma leucorhoa*) burrows; dead petrel chick) in the area.

FIGURE 1. Incubating Northern Fulmar on a ledge near the top of a cliff on Baccalieu Island, 27 May 1977.

FIGURE 2. Newly hatched Northern Fulmar on Funk Island, 10 July 1977.

Four pairs of fulmars were seen occupying four cliff-ledge sites on 1, 3, and 8 June in Bull Gulch just north of Gannet Head on the east side of the island about 1.5 km south of Jackson Gulch. No fulmars were seen in this area from 7 to 12 August. The behavior and temporary site tenacity of these birds suggested they were "prospecting" (Fisher 1952; Nettleship and Lock 1973). Northern Fulmars have been observed on Baccalieu Island as long ago as 1959 (Rice). Future checks on colonization in this area will be made.

On 9–10 July 1977 Montevecchi and Porter found three fulmars with eggs on Funk Island, two nesting on flat ground, the other on a ledge about 1.5 m above ground. In the two nests checked, one egg hatched on 10 July (Figure 2), the other pipped on 11 July, indicating that egg-laying occurred toward the end of May. This is consistent with the timing of egg-laying on Baccalieu and in the boreal North Atlantic in general (Fisher 1952).

Baccalieu Island is the third island off Newfoundland where Northern Fulmars have been found breeding in 4 years, and breeding attempts in Labrador (Nettleship and Lock 1973) and along the Avalon Peninsula of Newfoundland (L.M. Tuck, personal communication) seem likely. The Northern Fulmars' potential for massive and sustained population increase as evidenced at colonies in Great Britain during the past and present centuries (Fisher 1952) leaves open the possibility that we may be witnessing the initial stages of what may soon be a population explosion of the species in the boreal Atlantic regions of Canada. Close watch should be kept for further breeding range expansion of these birds, and breeding censuses at known nesting areas should be made regularly. The light-phase plumage of all Northern Fulmars found nesting or "prospecting" in Newfoundland-Labrador suggests that these birds may be immigrating from colonies in western Greenland, Iceland, or Great Britain (Fisher 1952; Salomonsen 1965; Brown 1970; Tuck 1971) rather than from the Canadian arctic region. Banding data and/or body (especially culmen) measurements (Salomonsen 1965) may help clarify this matter in the future.

We are grateful to the Newfoundland Wildlife Division and the Canadian Wildlife Service for permission to work in these locations, to Bruce Bursey and Dr. Leslie M. Tuck for helpful suggestions, and to Raymond Hyde, Felix Noonan, and Linus Walsh for their hospitality on Baccalieu Island. Financial support was provided by National Research Council of Canada Grant No. A0687 awarded to W. A. Montevecchi.

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Life History Observations on the Nudibranch Mollusc *Onchidoris bilamellata* in the Intertidal Zone of Nova Scotia

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Bleakney, J. Sherman and Constance L. Saunders. 1978. Life history observations on the nudibranch mollusc *Onchidoris bilamellata* in the intertidal zone of Nova Scotia. Canadian Field-Naturalist 92(1): 82–85.

Analysis of Nova Scotia collections of the nudibranch *Onchidoris bilamellata* (L., 1767) from 1967 to 1977 demonstrates an annual die-off of the adult population between May and July. This is also observed in European populations of this species. Spawning normally extends from January to May but juveniles could not be found before late July or August.

Key Words: dorid nudibranch, *Onchidoris bilamellata,* life history, annual species, Nova Scotia, Minas Basin.

Dorid nudibranchs are carnivorous gastropod molluscs found in a great variety of marine habitats. *Onchidoris bilamellata* (L., 1767) is a seasonally common intertidal species of rocky shores, where it preys upon *Balanus balanoides* and other species of barnacles. It is a widely distributed species of boreal and sub-arctic seas of the Northern Hemisphere with a northern limit near 70° N. On the European coast it appears as far south as Sandgate, South Kent, England, and at Winereux, Pat de Calais, France. Along the northwest Atlantic shores Connecticut is evidently the southern limit.

This dorid is evidently an annual and the adults reportedly die in early summer after spawning. Therefore, it is rarely encountered in summer when field survey crews are most active. As the basic life history of this major winter predator of barnacles has been investigated only in England, our Nova Scotia data represent the first comparative study of populations from the western Atlantic.

Recent literature includes distributional reports from the northeast and northwest Atlantic coasts (Miller 1961; Swennen 1961; Franz 1970; Potts 1970; Meyer 1971). The life cycle of *O. bilamellata* in Europe, however, has been studied only in England and that was based on data from fewer than 3 years, 1964–1966 (Potts 1970). Clark (1975) described the life cycles of 24 species of Atlantic nudibranchs, including *O. bilamellata,* based on 4 years of observation of the Connecticut fauna. Unfortunately this species is rare at that latitude and Clark's data are inadequate for critical comparison with those of Potts and the present study. The seasonal occurrence of *O. bilamellata* on the Pacific coast of Washington State was mentioned incidentally by Connell (1970) and Dayton (1971) in connection with their *Balanus* studies.

Study Areas

Our collections are from Annapolis and Kings Counties, Nova Scotia, particularly along the western shores of the Minas Basin area (Figure 1). The Bay of Fundy coast of southwestern Nova Scotia is composed of basalt, an ideal substrate for barnacles, and rocks from this ridge are scattered over the sandstone, sands, and muds of the extensive eulittoral zone of the Minas Basin and Annapolis Basin. The most conspicuous and consistently present barnacle predator on these rocks is the dogwinkle *Nucella lapillus.* Purple and white varieties of the predaceous dorid *Acanthodoris pilosa* are often associated with *O. bilamellata,* but they are feeding solely upon the encrusting ectoproct colonies of *Alcyonidium polyoum.* More extensive descriptions of the two

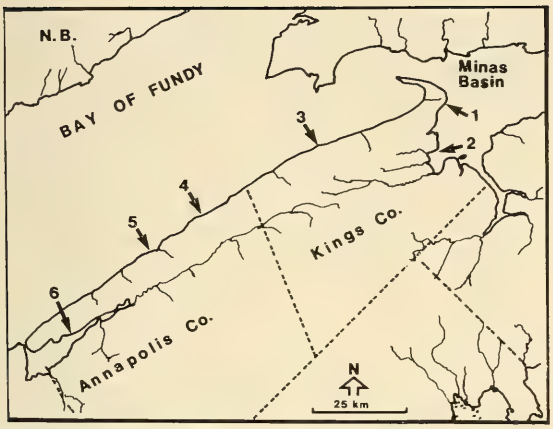

FIGURE 1. Map of the six areas in Annapolis and Kings Counties where *Onchidoris bilamellata* was collected. Major sites are 1, Cape Blomidon; 2, Kingsport; and 3, Black Rock. Of lesser importance were 4, Port George; 5, Hampton; and 6, Port Royal.

Minas Basin study sites, Cape Blomidon and Kingsport, have been published previously (Bleakney and McAllister 1973; Bleakney and Mustard 1974).

Methods

Our general collections of nudibranchs taken at extreme low tides were begun on a year-round basis in 1967, although the annual emphasis varied relative to species and habitats. Table 1 summarizes a 10-year accumulation of observations of *bilamellata*.

During field excursions, populations of *O. bilamellata* were often observed but not collected particularly if we already had data from that time period. Thus the many blanks in Table 1 do not necessarily indicate the species' absence nor a cessation of field activities for that month. Only representative size-range samples were collected because any regular intensive collecting aimed at determination of population size-class changes could decimate local restricted populations. At any one time most individuals were similar in size and after collecting several of these efforts were concentrated on finding any larger or smaller specimens. This size range information, based on 58 collections totalling 453 specimens, is presented in Figure 2.

Results and Discussion

It is evident from the information provided by Potts (1970) and by our observations in Nova Scotia, that *O. bilamellata* is an annual species but the basic pattern is not rigidly fitted to calendar months. For example, Potts determined that in 1964 the adults were absent from 10 May to 30 July but in 1965 they were absent for a 6-month period from 29 April to 16 October. Similarly, in Nova Scotia 1969 was exceptional. Spawn from this species has been found in all months from January through July (Figure 2), but on 16 field trips in June and July only in 1969 were adults and/or spawn found (once in June and three times in July). Apparently on both sides of the Atlantic egg laying is concentrated in the cold-water months of January through April but remarkably the species is capable of living and spawning on into July, at least in the Minas Basin. Meyer (1971) failed to find *O. bilamellata* along the coast of Nova Scotia in June and July of 1968, except at Kingsport, Minas Basin. (Date of capture and size of specimens were not reported.) Data on growth and on spawning in Washington State are lacking but the species has been observed intertidally only from September to March (Dayton 1971).

In England the smallest individuals were found in July and August (Potts 1970), while in Nova Scotia they were found in August and September. On the

TABLE 1—Distribution of 73 documented field trips by year and month in search of *Onchidoris bilamellata* in Kings and Annapolis Counties, Nova Scotia. Inclusive unproductive trips are bracketed. The 58 collections contained 453 specimens

Year	Trips/yr	Months											
		J	F	M	A	M	J	J	A	S	O	N	D
1967	2	—	—	—	1	1	—	—	—	—	—	—	—
1968	3	—	—	—	—	—	—	—	—	—	2	1	—
1969	12	1	1	—	—	2	3(2)	4(2)	—	—	1	—	—
1970	12	1	2(1)	2	—	—	—	—	3	1	—	2	1
1971	4	—	2	1	—	—	—	—	—	—	1	—	—
1972	2	—	—	—	—	—	—	—	—	—	—	2(1)	—
1973	4	—	—	1	—	2	—	—	—	—	—	1	—
1974	4	2	—	—	—	—	—	—	—	—	2	—	—
1975	3	—	1	—	—	—	—	—	(1)	—	1	—	—
1976	20	—	1	2	—	1	3(3)	4(3)	3	2	3	1	—
1977	7	—	1	1	—	1	1(1)	1(1)	1	1			
Total trips		4	8(1)	7	1	7	7(6)	9(6)	7(1)	4	10	7(1)	1
Total specimens collected		10	25	73	0	30	0	30	11	63	73	111	27

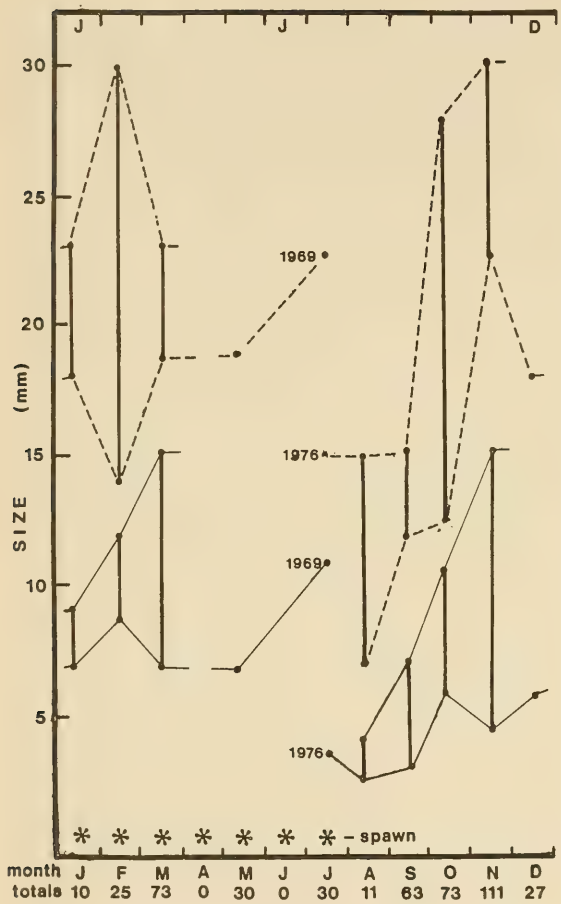

FIGURE 2. A monthly summary of size range distribution of the largest (upper graph) and smaller (lower graph) individuals of *Onchidoris bilamellata* collected in Nova Scotia from 1967 to 1977. For each month there is an upper set of lines showing the size range of the largest individuals from every collection over this time period, and below is a similar vertical line showing the size range of the smallest individuals from the same collections. Note that in 1969 the July population consisted of adults whereas only juveniles were present in 1976. There is an evident annual population die-off of adults from May to July.

Pacific coast small individuals invaded screened barnacle cages only between September and December (Connell 1970), again indicating an annual recruitment of juveniles.

Individuals apparently grow rather rapidly, for Nova Scotia collections from October and November have specimens of maximum size. In November 1968 and 1970, February 1969, and October 1969, maxima near 30 mm were noted. This is 5–7 mm larger than most of Potts' 613 British specimens. These large individuals could well be peculiar to those years, as we have noticed that other species of nudibranchs (and sacoglossans) may sporadically produce populations of mega-individuals. It is evident from examination of Figure 2, that over a 10-year period the size range in any one month can vary considerably within the two categories of largest and smallest individuals. This could be the result of increased or decreased growth rate for that year or an earlier or later recruitment of juveniles. July 1969 was unusual in that large spawning adults were still active in Minas Basin. Sampling the same areas in July 1976 yielded only juveniles.

Potts and Clark failed to emphasize both the peculiar and the enigmatic aspects of reproduction in *O. bilamellata*. First, the species must grow to near maximum size before spawning (Potts 1970). This is peculiar because many other opisthobranchs spawn at sizes of only several millimetres and continue to spawn as they increase in size. Second, the fate of the veligers that hatch from December through May is an enigma. Hadfield (1963) was determined that hatching (near Denmark) takes about 8–9 days and the free swimming veliger larval stage can be extended in the laboratory for 32 days. Clark (1975) listed eight cold-water species including *O. bilamellata* appearing in Connecticut that have an interval of at least 5 months between disappearance of the adults and the first appearance of the juveniles. He concluded that local populations were not self-sustaining, but received a periodic influx of larvae from further north where populations are probably present most of the year. Our evidence from Nova Scotia and England does not support his assumption of nearly year-round larval production farther north. Potts concluded that juveniles in his area in England might be recruited from some distant population and stated that in spite of the long breeding season, only eggs laid towards the end of that season were likely to be of any value in the recruitment of the next population. Unfortunately, the maximum free-living veliger larval period is not known, but any period longer than 2 months seems unreasonable in the light of Hadfield's experiments. Yet the Nova Scotia and British collections demonstrate an absence of juveniles until 8 months after the first eggs are laid.

Remarks

Rather than attempt speculative conclusions, we feel obliged to state pertinent questions. Why does the characteristic early winter spawning persist year after year if there are no survivors from this genetic component of the population? Why are the minimal juvenile size classes of 2–5 mm in Nova Scotia and England found only in July, August, and September? Why is there such a range in body length from 5 to

30 mm in November in Nova Scotia if these individuals are from the same invasive recruitment of August or September? If they represent an invasion from an offshore deep-water winter population then many should have 6 to 8 months growth by August. Why should the winter juveniles restrict themselves to offshore waters from January to August when most of the population is in the intertidal balanoid zone?

On the evidence from both sides of the Atlantic one can conclude, albeit unreasonably, that after 6 months of spawning the entire population of adults and juveniles dies out in May or June only to be replaced 60–90 days later in August and September by individuals 2 to 5 mm long. Although *O. bilamellata* is a common amphiatlantic boreal dorid nudibranch and has been neatly categorized as an annual species, it exhibits an enigmatic recruitment pattern.

The National Research Council of Canada (Grant A2009) provided the basic funding for our long-term molluscan studies.

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Additions to the Flora of Alberta and New Records

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Smoliak, Sylvester and Alexander Johnson. 1978. Additions to the flora of Alberta and new records. Canadian Field-Naturalist 92(1): 85–89.

A list of 70 vascular plant species collected in southern Alberta is presented to amend Moss' *Flora of Alberta*. The list includes plants not listed by Moss or those he listed as being rare or expected in the area.

Key Words: Alberta flora, new additions, new records.

The standard taxonomic reference text in Alberta is E. H. Moss' *Flora of Alberta*. Since its appearance in 1959, studies of the flora of the province have increased considerably, notably at the Universities of Alberta, Calgary, and Lethbridge and at the Lethbridge Research Station of Agriculture Canada.

At the Lethbridge Research Station, the development and maintenance of a herbarium is the responsibility of range management specialists who use the herbarium for range inventories. Range inventories are basic to land-use planning and must adequately describe and evaluate resources to allow determination of the capability of the land to support livestock and wildlife and to identify areas of critical environmental concern.

A key to the preparation of an inventory of rangeland is the vegetation, and a good range inventory showing the plant species, soils, geographic conditions, and rainfall is essential in determining the numbers of livestock that can be supported on any range.

Since 1959, the herbarium collection at the

Lethbridge Research Station has nearly doubled. Collectors during the period included T. D. Allen, G. Bohus, R. G. Gschaid, A. Johnston, J. J. Sexsmith, and S. Smoliak. The herbarium collections generally have been limited to the flora of southern Alberta.

The herbarium contains 6848 specimens representing 99 families, 463 genera, and 1033 species. The systematic arrangement of the herbarium, following the numbering system of Rydberg (1932), provided an opportunity to itemize the collections on computer cards and tape. The computerized printout is used to provide an updated inventory of the herbarium. It has also enabled us to compare the contents of the Lethbridge Research Station herbarium with species described in the *Flora of Alberta* (Moss 1959).

The voucher specimens of the additions listed below are retained in the herbarium at the Lethbridge Research Station. Some additional specimens are also deposited in the herbarium of Agriculture Canada, Biosystematics Research Institute, Ottawa. Most of the 70 species listed have been identified or verified by the personnel of the Cultivated Crop and the Noxious and Native Plant Sections, Biosystematics Research Institute, Ottawa, and are listed by Boivin (1967, 1969, 1972) as occurring in Alberta. The nomenclature follows that of Boivin (1967, 1969, 1972) or in some instances Hitchcock and Conquist (1973). The native species are marked with an asterisk.

The following abbreviations have been used in the listing: LRS, Lethbridge Research Station; MRS, Manyberries Research Substation; SRS, Stavely Research Substation.

Species List

GRAMINEAE

Agropyron desertorum Fisch.
MRS. Roadsides. 25 June 1973. Gschaid, Smoliak, and Allen 2854.
Not previously reported for Alberta.

Agropyron elongatum (Host) Beauv.
LRS. Irrigated areas. 7 August 1973. Allen 2975.
Not previously reported for Alberta.

Agropyron trichophorum (Link) Richt.
MRS. Roadside. 27 June 1973. Smoliak and Gschaid 2860.
Not previously reported for Alberta.

Elymus angustus Trin.
MRS. Dryland. 27 June 1973. Smoliak and Gschaid 2861.
Not previously reported for Alberta.

Elymus junceus Fisch.
MRS. Roadsides. 9 June 1948. Hubbard 1369.
LRS. Dryland, 18 August 1969. Allen 2463.
MRS. Fields and roadsides. 31 May 1972. Gschaid and Allen 2699.
Not previously reported for Alberta.

Lolium temulentum L.
Edmonton. Garden. 8 September 1938. Sexsmith 1153.
Foremost. Roadside. 3 July 1975. Coukell 3251.
Not previously reported for Alberta.

Panicum capillare L.*
Brooks. Shore of Lake Newell. 19 September 1973. Smoliak, Gschaid, and Allen 3032.
Not previously reported for Alberta.

Poa nevadensis Vasey*
MRS. Moist coulee. 19 June 1973. Smoliak, Gschaid, and Allen 2851.
Not previously reported for Alberta.

Puccinellia cusickii Weath.*
MRS. Moist coulee. 19 June 1973. Smoliak, Gschaid, and Allen 2852.
Not previously reported for Alberta.

Sorghum vulgare Pers.
LRS. Irrigated land. 14 August 1940. Peake 1223.
Not previously reported for Alberta.

LILIACEAE

Asparagus officinalis L.
Lethbridge. Oldman River valley. 18 August 1971. Gschaid and Allen 2673.
Not previously reported for Alberta.

SALICACEAE

Salix fluviatilis Nutt.*
MRS. Near dam. 18 May 1973. Gschaid and Allen 2838.
Raymond. Near irrigation canal. 16 July 1973. Bohus 2903.
MRS. Roadside ditch. 5 September 1973. Smoliak, Gschaid, and Allen 3037.
Reported by Boivin (1967).

CANNABINACEAE

Cannabis sativa L.
Lethbridge. No location. August 1938. Peake 1138.
Reported by Boivin (1967).

POLYGONACEAE

Fagropyrum esculentum Moench
Lethbridge. No location. September 1917. Hirst 72.
Reported by Boivin (1969).

Polygonum erectum L.*
Bow Island. Sandy area. 17 July 1967. Allen and Gschaid 2125.
Reported by Boivin (1969).

Rumex crispus L.
Raymond. Irrigation canal. 16 July 1973. Bohus 2905.
Not common in Alberta (Moss 1959). Reported by Boivin (1969).

CHENOPODIACEAE

Atriplex heterosperma Bunge
Walsh. Alkaline area. 26 June 1969. Gschaid and Allen 2398.
Reported by Frankton and Bassett (1968).

Atriplex oblongifolia Waldst. et Kit
Lethbridge. Oldman River valley. 30 August 1971. Gschaid and Allen 2676.
Not previously reported for Alberta.

Atriplex powellii Wats.*
Reported by Boivin (1969) and Frankton and Bassett (1970).

Atriplex truncata (Torr.) Gray*
Reported by Frankton and Bassett (1970).

NYCTAGINACEAE

Abronia micrantha Torr.*
MRS. Sandy area. 19 July 1977. Smoliak 3462.
Reported by Boivin (1967) and Johnson and Hallworth (1975).

CARYOPHYLLACEAE

Cerastium fontanum Baumg. subsp. *triviale* (Murb.) Jalas
West Castle. Gravelly roadside. 27 May 1969. Smoliak, Gschaid, and Allen 2347.
Not previously reported for Alberta.

Saponaria officinalis L.
Lethbridge. Dry roadside. 14 August 1972. Gschaid and Allen 2750.
Lethbridge. Oldman River valley. 19 August 1972. Allen 2750a.
Carmangay. Roadside. 15 July 1976. Gschaid and Kesler 3417.
Rare in Alberta (Moss 1959). Reported by Boivin (1969).

RANUNCULACEAE

Myosurus aristata Benth. subsp. *montanus* (Campbell) Stone*
MRS. Alkaline slough. 8 June 1937. Campbell 1974.
MRS. Slough edge. 3 May 1964. Smoliak 1929.
MRS. Dry creek bed. 10 July 1967. Allen and Gschaid 2126.
Not common in Alberta (Moss 1959).

CRUCIFERAE

Alyssum desertorum Stapf
Winnifred. Alfalfa field. 8 May 1968. Sexsmith 2174.
Lundbreck Falls. Gravelly area. 14 May 1969. Allen and Gschaid 2356.
Reported by Boivin (1969).

Arabis microphylla Nutt.*
Magrath. Bromegrass field. 14 July 1963. Allen and Johnston 1917.
Not previously reported for Alberta.

Barbarea vulgaris R. Br.
Oliver. Roadside meadow. 5 June 1938. Sexsmith 1065.
Not common in Alberta (Moss 1959).

Brassica nigra (L.) Koch
Lethbridge. Six Mile Coulee. 26 July 1971. Allen and Gschaid 2650.
Expected in Alberta (Moss 1959).

Lepidium latifolium L.
Magrath. No location. 20 June 1932. No name 542.
Lethbridge. Slough edge. 10 August 1951. Hobbs 1532.
Raymond. Roadside. 1 August 1967. Allen and Gschaid 2157.
Stewart. Fields and roadsides. 31 July 1970. Smoliak and Allen 2515.
Rare in Alberta (Moss 1959). Reported by Boivin (1969).

Raphanus raphanistrum L.
Pincher Creek. Moist ditch. 11 July 1972. Gschaid and Allen 2756.
Rare in Alberta (Moss 1959). Reported by Boivin (1969).

SAXIFRAGACEAE

Conimetella williamsii (Eaton) Rydb.*
Bobs Creek. Woods. 28 July 1973. Allen 2918.
Reported by Boivin (1969) and Packer and Dumais (1972).

LEGUMINOSAE

Astragalus cicer L.
LRS. Irrigated plot area. 15 July 1941. Johnston 1289.
MRS. Irrigated field. 30 July 1948. Hubbard 1391.
LRS. Roadside. 11 July 1973. Gschaid and Allen 2931.
MRS. Cultivated area. 5 September 1973. Gschaid, Smoliak, and Allen 3050.
LRS. Machine yard. 2 July 1974. Bohus 3148.

Astragalus falcatus Lam.
LRS. Irrigated plot area. 5 August 1975. Smoliak 3325.
Not previously reported for Alberta.

Lotus corniculatus L.
LRS. Roadside. 11 July 1973. Gschaid and Allen 2928.
Lethbridge. Waste area. 21 June 1974. Bohus 3113.
Reported by Boivin (1967).

Onobrychis viciaefolia Scop.
LRS. Dryland plot area. 20 July 1917. Hirst 47.
LRS. Waste area. 2 July 1974. Bohus 3149.
Not previously reported for Alberta.

Ornithopus roseus Duf.
Edmonton. Garden. 8 September 1938. Sexsmith 1158.
Not previously reported for Alberta.

Trifolium agrarium L.
Waterton Lakes National Park. Moist roadside. 8 July 1969. Allen 2448.
Allison Lake. Lake shore. 20 July 1970. Allan and Allen 2521.
Pincher Creek. Roadside. 6 July 1973. Smoliak, Gschaid, and Allen 2924.
Very rare in Alberta (Moss 1959). Reported by Boivin (1967).

Trifolium fragiferum L.
Edmonton. University farm. 31 August 1938. Sexsmith 1142.
Lethbridge. Six Mile Coulee. 26 July 1971. Allen and Gschaid 2656.
Not previously reported for Alberta.

Trifolium procumbens L.
Edmonton. University farm. 31 August 1938. Sexsmith 1141.
Edmonton. Railway embankment. 12 September 1938. Sexsmith 1157.
Reported by Boivin (1967).

Trigonella coerulea (L.) Ser.
Lethbridge. Irrigated field. 13 July 1938. Sexsmith 1115.
Reported by Boivin (1967).

GERANIACAE

Erodium cicutarium (L.) L'Her
Raymond. Dryland. 10 August 1937. Sexsmith 1033.
Raymond. Newly seeded field. 7 August 1970. King 2562.
LRS. Irrigated plot area. 28 June 1974. Bohus and Dalton 3120.
Rare in Alberta (Moss 1959). Reported by Boivin (1972).

OXALIDACEAE

Oxalis corniculata L.

LRS. Greenhouse. 13 March 1975. Bohus 3184.

Reported by Boivin (1972) and Packer and Dumais (1972).

ZYGOPHYLLACEAE

Zygophyllum fabago L.

LRS. Irrigated plot area. 12 August 1968. Hanna 2307.

LRS. Irrigated plot area. 15 September 1968. Hanna 2325.

Not previously reported for Alberta.

EUPHORBIACEAE

Euphorbia peplus L.

Raymond. Garden. 27 September 1974. Bohus 3178.

Not previously reported for Alberta.

VIOLACEAE

Viola cucullata Ait.*

SRS. Moist coulee. 14 May 1971. Allen 2595.

Reported by Boivin (1967).

UMBELLIFERAE

Anethum graveolens L.

Lethbridge. Waste areas and back alleys. 11 July 1971. Allen 2626.

Reported by Boivin (1967) and Packer and Dumais (1972).

ERICACEAE

Menziesia ferruginea Smith*

Racehorse Creek. Open woods. 6 June 1969. Allen and Johnston 2427.

Reported by Boivin (1967).

CONVOLVULACEAE

Cuscuta umbrosa Hook.*

Lethbridge. Oldman River valley. 30 August 1971. Gschaid and Allen 2680.

Apparently rare in Alberta (Moss 1959). Reported by Boivin (1972).

BORAGINACEAE

Symphytum officinale L.

LRS. Irrigated plot area. 25 June 1973. Allen 2889.

LRS. Irrigated pasture area. 18 July 1975. Smoliak and Gschaid 3314.

Reported as being an escape (Moss 1959). Reported by Boivin (1972).

LABIATAE

Moldavica thymiflora (L.) Rydb.

Porcupine Hills. Waldron ranch roadside. 6 June 1969. Allen and Johnston 2430.

Whaleback Ridge. Dry shale slope. 21 June 1972. Allen 2729.

Rare in Alberta (Moss 1959). Reported by Boivin (1972).

Nepeta cataria L.

Lethbridge. Oldman River valley. 2 August 1968. Allen 2311.

Magrath. Creek area. 5 August 1976. Smoliak 3429.

Very rare in Alberta (Moss 1959). Reported by Boivin (1972).

Salvia nemorosa L.

Monarch. River valley. 20 July 1935. No name 875.

Claresholm. Dry roadside. 29 July 1966. Allen and Gschaid 2072.

Rare in Alberta (Moss 1959). Reported by Boivin (1972).

SOLANACEAE

Solanum rostratum Dunal*

Pincher Creek. Roadside. 24 August 1966. Kettles 2098.

Reported by Boivin (1972) and Packer and Dumais (1972).

SCROPHULARIACEAE

Castilleja sessiliflora Pursh*

MRS. Sandy area. 30 June 1975. Smoliak and Berg 3213.

MRS. Sandy area. 3 June 1976. Smoliak and Gschaid 3399.

Not previously reported for Alberta.

Penstemon fruticosus (Pursh) Greene subsp. *scouleri* (Lindl.) Penn. and Keck*

Crowsnest Pass. Rocky banks. 1 July 1932. White 674.

Apparently rare in Alberta (Moss 1959). Reported by Boivin (1972).

Penstemon montanus Greene*

Prairie Bluff Mountain. Open pine woods. 12 July 1966. Allen and Gschaid 2074.

Not previously reported for Alberta.

LOBELIACEAE

Downwingia laeta Greene*

Walsh. Mud and shallow water. 26 June 1969. Gschaid and Allen 2434.

Rare in Alberta (Moss 1959). Reported by Boivin (1972).

COMPOSITAE

Anthemis tinctoria L.

Waterton Lakes National Park. Waste area. 1 September 1974. Bohus 3182.

Uncommon in Alberta (Moss 1959). Reported by Boivin (1972).

Aster maccallae Rydb.*

Allison Lake. Moist shaded area. 22 August 1972. Gschaid and Allen 2814.

Reported by Porsild (1959), Boivin (1972), and Packer and Dumais (1972).

Aster simplex Willd.*

Lethbridge. Oldman River valley. 4 September 1972. Allen 2824.

SRS. Moist coulee. 15 September 1973. Allen 3060.

Not previously reported for Alberta.

Bahia oppositifolia (Nutt.) DC*

West Lethbridge. Cultivated field. 15 July 1969. Sexsmith 2458.

Found locally near Lethbridge (Moss 1959). Reported by Boivin (1972).

Centaurea diffusa Lam.

Crowsnest Pass. Roadside. 10 September 1973. Williamson, Gschaid, and Allen 3065.

Reported by Boivin (1972) and Packer and Dumais (1972).

Centaurea maculosa Lam.

Waterton Lakes National Park. Roadside. 2 September 1967. Allen, Smoliak, and Gschaid 2153.

Crowsnest Pass. Roadside. 22 August 1972. Gschaid

and Allen 2820.
Kipp. Roadside. 3 August 1973. Gschaid 3027. Not previously reported for Alberta.

Cichorium intybus L.
Lethbridge. Roadside. 5 August 1942. Sexsmith 1323. Apparently rare in Alberta (Moss 1959). Reported by Boivin (1972).

Chrysanthemum leucanthemum L.
Crowsnest Pass. No location. 1 July 1932. White 695.
Hillcrest. Open woods. 29 June 1958. Johnston and Allen 1745.
Allison Creek. Clearing. 3 October 1962. Allen 1913.
LRS. Shaded area. 12 June 1973. Smoliak and Allen 2893.
Waterton Lakes National Park. Roadside. 1 September 1974. Bohus 3183.
Reported for few localities (Moss 1959). Reported by Boivin (1972).

Hieracium aurantiacum L.
Cardston. Lawn. 20 June 1972. Steed 2739.
Rare in Alberta (Moss 1959). Reported by Boivin (1972).

Senecio foetidus Howell*
Beauvais Lake. Moist woods. 1 July 1964. Sexsmith 1959.
Pincher Creek. Moist meadow. 11 July 1972. Gschaid and Allen 2789.
Reported by Boivin (1972) and Packer and Dumais (1972).

Silybum marianum (L.) Gaertn.
Coaldale. Cultivated area. 12 September 1973. Allen 3064.
LRS. Greenhouse. 4 April 1975. Bohus 3187.
Reported by Boivin (1972).

Sonchus oleraceus L.
Lethbridge. Garden. 2 August 1970. Allen 2578.
Not common in Alberta (Moss 1959). Reported by Boivin (1972).

Townsendia hookeri Beaman*
Lethbridge. Coulee slope. 23 April 1969. Smoliak and Allen 2340.
SRS. Gravelly ridge. 20 May 1970. Allen 2488.
Reported by Beaman (1957).

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European Flounder (*Platichthys flesus*) Captured in Lake Erie, Ontario

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Emery, A. R. and G. Teleki. 1978. European Flounder (*Platichthys flesus*) captured in Lake Erie, Ontario. Canadian Field-Naturalist 92(1): 89–91.

Two specimens of *Platichthys flesus,* the flounder, from Europe, were captured alive in different localities in Lake Erie, far from the fish's normal oceanic or estuarine habitat. Evidence from stomach contents suggested some residence time in the lake and immigration is speculated to have been via a ship's ballast tank.

Key Words: flounder, *Platichthys flesus,* Lake Erie, exotic species, zoogeography, introduction.

The Flounder, *Platichthys flesus*, normally occurs in European waters of the Atlantic north to the White Sea, but is also known from the Adriatic and Black Seas. It is particularly common in the Baltic Sea, and also the southern and eastern coastal North Sea (Wheeler 1969). This flounder is well known as the only European flatfish to penetrate well into estuaries and to live in fresh water for periods of time. It is common in water shallower than 55 m, and makes extensive migrations (30 to 60 km), although many marked flounders have been observed not to migrate significantly. Entries into fresh water are noted mainly in the summer but no spawning has been observed there.

The first specimen captured in Lake Erie was taken by a bait seine off Nigger Road, on Long Point, Ontario, some 1200 to 1500 km from the nearest brackish-water incursion into the Gulf of St. Lawrence and almost a quarter of the way around the world from its normal range.

The specimen (Figure 1) was captured alive on 3 July 1974 at 1000 hours in 1 m of water along a sand and gravel beach. It was measured and photographed prior to preservation (Royal Ontario Museum No. 30521).

The fish was 187.7 mm total length (158.3 mm standard length) and an examination of 10 scales suggested an age of 2 years. This showed about the average growth rate recorded by Wheeler (1969) for European waters. Two of the scales were regenerated, a not unusual proportion.

Stomach contents were examined, and although preservation was poor, because of the digestion that had taken place, R. McKay (University of Toronto) confirmed that the chironomids that made up part of the stomach contents were typical freshwater forms. Specific identification was not possible. Small clam shells, also present in the contents, were examined by D. G. Cook (formerly at Canada Centre for Inland Waters); he confirmed that these were in the genus *Pisidium*. *Pisidium* spp. are abundant small bivalve clams in the Great Lakes and possess unique features that make it difficult to confuse with marine or brackish-water forms.

The second specimen was captured a year and a half later on 3 January 1976, by Robert Foote of Port Burwell, Ontario. It was taken with trawling gear at a depth of "120 to 130 ft of water" (37 to 40 m), about 2 mi (3.2 km) south of Port Dover on Lake Erie. It was kept alive by Mr. Foote for approximately 5 h after capture. This specimen was considerably larger (347 mm total length) and had been gutted before being iced and brought to our attention.

This species is normally dextral. The first and smaller specimen was dextral, but the second and larger specimen was sinistral. In both cases, the specimens were in excellent condition with no evidence of broken fins or damaged scalation.

We wondered whether the specimens might be the result of a hoax, and have gone to some effort to establish the veracity of the records. We are now convinced of the integrity of the collectors. Their

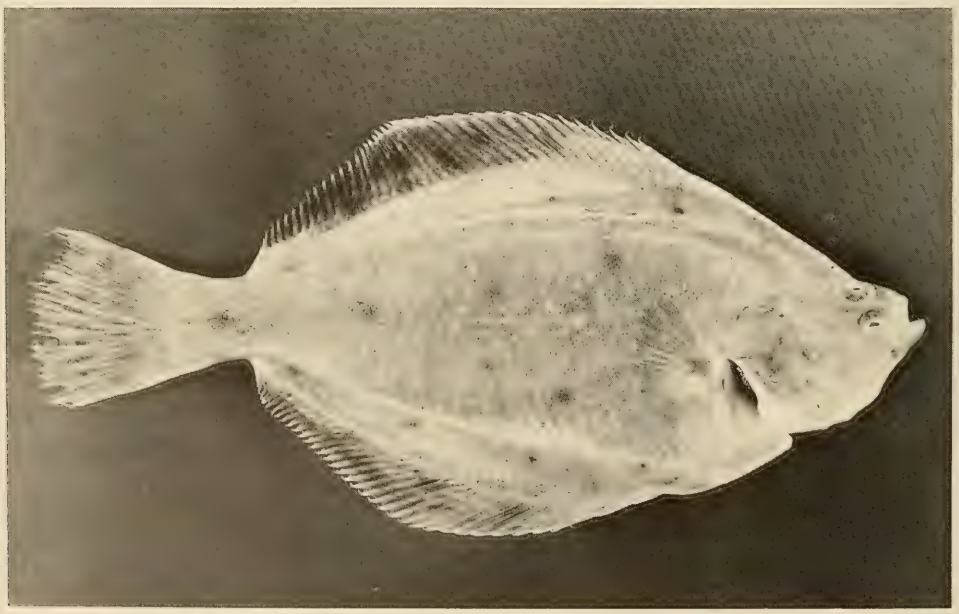

FIGURE 1. A European Flounder, *Platichthys flesus* (ROM 30521), 187.7 m total length, taken from Lake Erie, Ontario on 3 July 1974.

claim that the fish had been taken in fresh water was confirmed, at least in the case of the smaller specimen, by the presence of typical freshwater organisms of types a fisherman would not "feed" a fish (*Pisidium* clams and chironomid larvae).

Although we are skeptical of any spectacular anomaly in the geographic range of an animal, Lake Erie has already seen the arrival and establishment of some species of marine fish. Unlike the flounder, however, these species (e.g., Rainbow Smelt, *Osmerus mordax;* Sea Lamprey, *Petromyzon marinus*; and Alewife, *Alosa pseudoharengus*) are anadromous and have landlocked examples in other areas and a history of occurrence in Lake Ontario. More recently, a large exotic crab, the Mitten Crab (*Eriocheir sinensis*) originally from northern China and first reported in Lake Erie in 1973 (Nepszy and Leach 1973) has, apparently, managed to reach the lake in numbers. Nepszy and Leach do not believe that it has established a reproductive population. This latter is an analogous situation to the European Flounder being found in Lake Erie.

The mode of arrival of the flounder and of the Mitten Crab may be similar: the ballast tanks of ocean-going vessels. We have no real proof in either case. A comparison of the Mitten Crab and the flounder as equally aggressive invaders of Lake Erie is appropriate; the Mitten Crab is extensively distributed in areas of Europe now (Hoestlandt 1959; Kaestner 1970). There is ample evidence of the flounder migrating into European fresh water. The speculation that the flounder may have access to Lake Erie regularly in the future, and the evidence provided by stomach contents that it can feed in fresh water suggests that it will be captured irregularly in the future. Because it moves into fresh water in Europe but cannot reproduce, indicates that there is little likelihood of a population of *Platichthys flesus* becoming established in Lake Erie.

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Site and Seasonal Variations in Food of Wolves, Algonquin Park, Ontario

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Theberge, John B., Sebastian M. Oosenbrug, and Douglas H. Pimlott. 1978. Site and seasonal variations in food of wolves, Algonquin Park, Ontario. Canadian Field-Naturalist 92(1): 91–94.

Wolf (*Canis lupus*) scats collected in Algonquin Provincial Park during the summer in 1971 and 1974 demonstrated that food items in scats at rendezvous sites differed from those in scats elsewhere. Beaver (*Castor canadensis*) was more common in the former. Since all five rendezvous sites were adjacent to active beaver colonies, it is apparent that local food resources were being exploited. White-tailed Deer (*Odocoileus virginianus*) was more common away from rendezvous sites. Winter scats differed from those of summer by having a greater percentage of deer hair and less of beaver.

Key Words: wolf, Algonquin Park, predation.

The food of wolves has changed markedly over the past decade in Algonquin Park, concurrent with a decline in deer and increase in beaver numbers (Voigt et al. 1976).

In summer wolf (*Canis lupus*) scats the frequency of occurrence of hair from White-tailed Deer (*Odocoileus virginianus*) dropped from 80.5% in the years 1959 to 1965 (Pimlott et al. 1969), to 33% in 1972 (Voigt et al. 1976), while that of Beaver (*Castor canadensis*) increased from 7.1% to 55%.

We collected 220 wolf scats in the summers of 1971 and 1974 from the central and southern parts of Algonquin Park, in the same but slightly larger area from which the collections of Pimlott et al. (1969) and Voigt et al. (1976) were made. Unlike these other collections, however, we subdivided our collection into winter and summer scats, and into summer scats collected at wolf rendezvous sites versus those collected away from rendezvous sites. Differences in these categories further elucidate the changes occurring in wolf-prey dynamics in Algonquin Park.

Study Area

Data were collected from approximately 1700 km^2 of central and southern Algonquin Park. Algonquin Park is situated near the southern edge of the Canadian Shield, with intrusive volcanic and metamorphic rocks forming rolling hills of elevation varying between 152 and 518 m. Forests exhibit an ecotonal position between Boreal and Great Lakes–St. Lawrence Regions (Rowe 1959). A more complete description of this area is given by Pimlott et al. (1969).

Methods

Throughout the study area, 220 scats were collected over the periods of May to September 1971 and 1974. Most scats (141) were found in general searches of the extensive network of logging roads and portage trails; an additional 79 were found at wolves' rendezvous sites, where packs commonly spend a week or more at a time throughout the summers (Joslin 1967). Rendezvous sites were located by giving vocal imitations of wolf howls to which wolves responded, taking bearings, and after the wolves left, by examining the area (D. H. Pimlott, 1960. The use of tape-recorded wolf howls to locate timber wolves. Twenty-second Midwest Fish and Wildlife Conference, Toronto. 7 pp. mimeo).

Scats were classified as winter (period of snow on ground; ungulates in winter pelage) or summer based on when scats were collected and how fresh they appeared. Winter scats were leached of all organic matter except hair and bones, were deposited without new green growth beneath them, and were found on the first passages of various routes. Scats classed as unknown age were not included in the analyses. Pup scats within the size range, which could be misidentified as those of Red Fox (*Vulpes vulpes*), were not collected except at rendezvous sites. No Coyotes (*Canis latrans*) have been reported in Algonquin Park to allow misidentification of scats.

Analysis of scats was done on the basis of the pattern and structure of cuticular scales of hair, as described by Williamson (1951). After being washed through a sieve, hairs in scats were spread out in petri dishes, and representative hairs were checked by making impressions in commercial gelva (polyvinyl acetate) and by examining them microscopically. A collection of hairs at the University of Waterloo from known species of wildlife, and the guide to cuticular hair scales (Adorjan and Kolenosky 1969) were used to identify the hairs in scats. The hairs of White-tailed Deer and Moose (*Alces alces*) were distinguished as from summer or winter, but we were unable to separate consistently and positively the hairs of young-of-the-year from adults for these two species.

For each scat, all species identified as food items were listed. Analysis was done on percent frequency of occurrence of food items to be consistent with analyses of earlier data. Scats collected in 1971 (124) and 1974 (96) were combined. Preliminary analyses by year showed no differences other than that attributable to smaller sample sizes.

Results

The 163 summer scats showed the following percent frequency of occurrence of hair: beaver, 49.0; deer, 28.9; moose, 14.7; and other, 7.3.

Significant differences were apparent when these scats were subdivided into those collected at wolf rendezvous sites and those collected in general searches elsewhere (Table 1). Beaver represented 62.8% of food items in scats at rendezvous sites (out of

TABLE 1—Percent frequency of food items in summer wolf scats collected in wolf rendezvous sites and in general searches, Algonquin Park, 1971 and 1974

Location of scats	Total scats	Beaver	Deer	Moose	Hare	Microtines	Other	Total items
Rendezvous sites	79	62.8	20.5	9.8	1.0	3.0	3.0	102
General search	84	35.3	37.3	19.5	2.0	3.0	3.0	102

a total of 102 food items), but only 35.3% in scats from elsewhere. Under-represented in scats collected at rendezvous sites was deer, which made up 20.5% of food items at rendezvous sites compared with 37.3% in general searches, and moose making up 9.8% and 19.5% respectively.

Food items that occurred infrequently in summer scats included Snowshoe Hare (*Lepus americanus*), 1.5%; small rodents either *Microtus pennsylvanicus, Peromyscus* sp., or *Synaptomys cooperi,* 2.4%; or Black Bear (*Ursus americanus*), 1.5%; and single occurrences of Eastern Chipmunk (*Tamias striatus*), Northern Flying Squirrel (*Glaucomys sabrinus*), raccoon (*Procyon lotor*), and fish scales. Four more occurrences of Black Bear hairs were found in scats collected at one rendezvous site, but these were not included because of the proximity of a dump where the Ontario Ministry of Natural Resources disposed of bears they killed.

Winter scats showed marked differences from summer scats. Our total of 78 food items in 57 scats showed the following percent frequencies of occurrence of hair: deer 64.0, moose 16.7, beaver 11.5, microtines 2.6, and other (Raccoon, bear, and Red Squirrel (*Tamiasciurus hudsonicus*)) 5.1. The first three species, when combined, contributed approximately the same amounts in summer (92.6%) as in winter (92.2%), but beaver hair was much less common in winter, and that of deer was more common.

Discussion

The food items in the summer scats were similar to those described by Voigt et al. (1976) for 1972, which showed occurrences for beaver and deer at 55% and 33% respectively. We found a greater occurrence of moose (14.7%) than did Voigt in 1972 (5%), but a similar percent to his 1969 figure (15%).

The differences in food items in summer scats collected at rendezvous sites compared with those collected elsewhere reflects general rather than absolute differences in what wolves eat in these places, because wolves may travel some distance after eating before they defecate. Some members of the pack, however, are more sedentary than others, such as a mother of pups (Murie 1944), and such animals likely contributed more to the collection at rendezvous sites. The difference in food items at, versus away from, rendezvous sites suggests that general collections of scats made to determine food habits should include scats found at rendezvous sites. We consider that our total summer collection provided as close to an accurate estimate of summer food habits as possible on the basis of equal representation of food items collected in both places (102 items each), and close to equal numbers of scats (79 and 84). Although no exact estimate can be made of the relative amounts of time that most members of the pack spend at or away from rendezvous sites, our best estimate is close to 50:50. Based on continuous observations at sites, Theberge and Pimlott (1969) observed that normally wolves spend most of the daylight hours at rendezvous sites and that at night most of the adults are away. All five rendezvous sites where we collected scats were within 0.5 km of active beaver colonies, as is often typical of such sites (Joslin 1967); hence, the higher proportion of beaver hair in scats collected there. Our results, demonstrating utilization by wolves of non-ungulate prey resources near rendezvous sites, contrasts with Peterson's (1974) conclusion that wolves on Isle Royale, Michigan, did not hunt beaver close to rendezvous sites.

Wolf scats representing the winter period, while small in sample size, show a marked difference from the 50 winter scats reported for 1962 by Pimlott et al. (1969). Deer hair dropped from 90% in 1962 to 64% in 1971–1974; moose and beaver hair combined increased from 10% to 27.2%. Although both samples are too small for detailed comparison, these results are consistent with those of Pimlott et al. (1969) who found deer hair more common in winter scats than in summer scats.

Acknowledgments

We thank graduate student David Gauthier, and undergraduate students Andrew Gordon and Owen Williams for their field assistance. Dan Strickland, Ministry of Natural Resources, and his naturalist staff provided many helpful observations. The study was funded in 1971 by a grant from the Elsa Wild Animal Appeal of Canada. The Ministry of Natural Resources sanctioned the study and gave us permission to use closed logging roads, which was essential to adequate coverage of the study area.

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Durability of Tree Holes Used by Buffleheads

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Erskine, A. J. 1978. Durability of tree holes used by Buffleheads. Canadian Field-Naturalist 92(1): 94–95.

Nesting studies of Buffleheads (*Bucephala albeola*) in the Cariboo parklands of British Columbia in 1957–1965 gave some data on permanence of nest sites (Erskine, A. J. 1972. Buffleheads. Canadian Wildlife Service, Monograph Series Number 4, Table 9). That period of study was too short to cover the potential durability of tree-hole nests. Accordingly, I revisited as many as possible of the former nest sites on 10–13 July 1975. This was after the nesting season, and only one site had clearly been used and two more possibly used in 1975. But more sites were still standing and apparently usable than had been predicted earlier: "About half of the known sites in aspens were no longer available six years after they were first found, and probably few last more than ten years... Over 80 per cent of nests in Douglas firs were still available four years later..." (Erskine, *op. cit.*, p. 69). Samples were then too small to extrapolate further.

The new data permit extension of the table, as

TABLE 1—Percentage of Bufflehead nests usable when revisited in subsequent years, British Columbia, 1957–1975

Nests in aspens				Nests in Douglas firs			
Years after nest first found	No. of nests visited	No. of nests usable	Percent still usable	Years after nest first found	No. of nests visited	No. of nests usable	Percent still usable
1	81	78	96	1	40	38	95
2	76	70	89	2	36	33	87
3	70	61	77	3	32	31	84
4	60	52	67	4	27	27	84
5	49	45	61	5	24	24	84
6	43	39	56	6	24	22	77
7	38	34	50	7	22	21	74
—	—	—	—	8	20	20	74
—	—	—	—	—	—	—	—
—	—	—	—	10	20	19	70
11	34	31	46	—	—	—	—
—	—	—	—	—	—	—	—
13	31	30	44	13	19	18	66
14	30	27	40	14	18	17	63
15	24	22	36	15	17	15	56
16	18	11	22	16	15	13	48
17	11	8	16	17	10	9	43
18	3	2		18	3	1	
19	—	—	—	—	—	—	—
20	—	—	—	—	—	—	—
21	—	—	—	21	1	1	

*Accumulated percent thus: 78/81 x 100 = 96; 78/81 x 70/76 x 100 = 89; etc.

follows: after 7 years, about one-half of all nests in trembling aspen (*Populus tremuloides*) and three-quarters of those in Douglas fir (*Pseudotsuga menziesii*) were still usable, whereas after 15 years about one-third of aspen nests and one-half of Douglas fir nests were usable. Compared to the earlier summary, the figures are similar up to 7 years (Table 1), but some nests were much more durable than had been thought. Possibly some trees were weakened by having been cut open or climbed during the intensive studies, and thus tended to fall soon afterwards, suggesting that sites were less durable than they actually were. Nevertheless, aspens are not long-lived trees, and the Douglas firs that contained nest holes were mostly already dead or broken off, so these data may be representative. Only four previously known trees with nest holes that were no longer present in 1975 had evidently been felled or cleared away deliberately (during cottage or resort development); the rest were judged to have fallen from more natural causes.

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Range Extensions to the Flora of the Eastern Canadian Arctic

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Jotcham, J. R. and S. P. Vander Kloet. 1978. Range extensions to the flora of the eastern Canadian Arctic. Canadian Field-Naturalist 92(1): 95–96.

The annual sovereignty mission by Maritime Command into the Arctic has afforded the staff and students of the E. C. Smith Herbarium an unparalleled opportunity to explore botanically unknown areas in the eastern Canadian Arctic. Although most of our interest has focussed on clarifying biosytematics of the polymorphic *Vaccinium uliginosum,* we have nevertheless accumulated distributional data of species associated with that species, some of which represent significant range extensions. Occasionally we visited a site where *V. uliginosum* was absent, in which case a general collection was made. A total of 146 species of vascular plants was collected over a 4-year period, 1972–1975. Specimen vouchers have been deposited in ACAD.*

Collections from some sites, such as Coburg Island (75°49′N, 79°27′W), Makinson Inlet (three sites: 77°19′N, 82°14′W; 77°16.5′N, 81°13′W; and 77°10.5′N, 81°35′W) are the first for these locations. No major extensions were noted at these sites. The specimens collected from Coburg Island were *Salix arctica, Cerastium alpinum, Draba bellii,* and *Cassiope tetragona.* Plants from the Makinson Inlet sites were *Carex rupestris, Carex misandra, Salix arctica, Polygonum viviparum, Papaver radicatum, Cochlearia officinalis, Draba bellii, Braya purpurasens, Saxifraga cernua, Saxifraga oppositifolia, Dryas integrifolia, Cassiope tetragona,* and *Pedicularis lanata.*

*Acronyms follow Index Herbariorum, Holmgren & Keuken (1974).

In addition, some species were collected from areas for which there seems to be no previous record, and range extensions are indicated for at least three species. These extensions are based primarily on distribution maps in Porsild (1964) and Hultén (1968), and from annotations on specimens deposited at CAN and DAO.

Poa alpigena var. *colpodea* — Occasional in wet gravel by river (Strathcona Sound, 73°07′N, 84°25′W; 1975.

This collection is on the eastern fringe of the known range for the Canadian Arctic. The variety also occurs in northern Greenland (Porsild 1964).

Dupontia fisheri ssp. *psilosantha* — Common in mesic gravel by river (Strathcona Sound, 1975).

This collection would be on the northern fringe of the range as indicated by distribution maps. CAN, however, has one collection from Expedition Fjord, Axel Heiberg Island (Beschel, CAN #293413). Our collection helps fill in the known distribution for this subspecies.

Juncus arcticus — Common in wet sand by river (Strathcona Sound, 1975).

Distribution maps for this species indicate a northern limit about 300 km farther south, near River Clyde on Baffin Island (Porsild 1964). CAN has one collection from Tanquary Fjord, Ellesmere Island, considerably to the north (G. R. Brassard, CAN #296268). Our collection helps to fill in this distributional gap.

Luzula spicata — Associated with *Vaccinium uliginosum* on exposed granitic soil (Pond Inlet, 72°38′N, 77°50′W; 1973).

This collection is a range extension of over 400 km to the north from previous collection sites at Cumberland Sound,

Baffin Island (Porsild 1964). This species is found at similar latitudes in Greenland (Porsild 1964).

Braya humilis ssp. *arctica* — Rare, on exposed gravel slopes (Strathcona Sound, 1975).

This collection is an extension to the south-east of the known range. Porsild (1964) shows collection points on Axel Heiberg Island and on Victoria Island. In addition, CAN has one collection from Irene Bay, Ellesmere Island, 72°02′N, 81°50′W (Irene Waterson #106/72).

Arctostaphylos rubra — Common on exposed rocky slopes (Strathcona Sound, 1975).

This collection is a range extension of over 400 km to the north. Porsild (1964) shows a collection site on West Baffin Island, just east of Prince Charles Island.

A complete species list of the plants collected is available and may be obtained by contacting the authors. It will be updated regularly with data from ongoing and future expeditions by Acadia University in conjunction with Maritime Command.

Acknowledgments

We express our great appreciation to the Department of National Defence, Maritime Command, for giving us the opportunity to explore the Canadian Arctic and providing logistical support. We also thank W. J. Cody of Agriculture Canada and J. M. Gillett of the National Museum of Natural Sciences for courtesies extended during the research in Ottawa. Thanks are due to G. W. Argus of the National Museum of Natural Sciences, M. Barkworth and G. A. Mulligan of Agriculture Canada for aid in identifying specimens. In addition, we are indebted to W. J. Cody for critically reading the manuscript and providing helpful suggestions.

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News and Comment

Notice of change to the By-Laws of The Ottawa Field-Naturalists' Club

A motion to change By-Law 2 of The Ottawa Field-Naturalists' Club was passed unanimously by the Council at the meeting of 3 October 1977.

This By-Law now reads as follows:

2. *Fiscal Year*

The fiscal year of the Club shall start at the beginning of October of any given year and shall end at the end of September of the following year.

Diana R. Laubitz,
Recording Secretary

Earthwatch — Offers Field Research to the Public

Earthwatch is a non-profit organization which offers people the chance to share the adventure and discoveries of field research. Earthwatch expeditions are open to anyone 16 to 75 and no special skills are required as participants are taught what they need to know in the field. Participants become working members of an expedition team and work under the supervision of a professional research scientist. They are required to make tax-deductible contributions of the order of $500 to $950 (usually for 2- or 3-week periods) to subsidize the research effort.

Since it began in 1971, Earthwatch has had nearly 2600 volunteers join research teams in support of over 300 scientists conducting research in 45 countries. Field research expeditions cover many disciplines, e.g., archaeology, anthropology, humanities, and earth, marine, and life sciences. In early 1978 volunteers will join expeditions to observe the behavior of the guanaco in the Andean foothills of southern Chile; record songs of the humpback whale; study tropical forest ecology; excavate a Mayan site in coastal Guatemala; study the coral reef ecosystem off Grenada; monitor raccoon movements by radio-telemetry; observe predator behavior towards small fish with different color patterns; study the response of gulls and terns to the declining water levels of the Great Lakes; etc.

All of the projects submitted to Earthwatch for support are first reviewed and approved by The Center of Field Research, which has an impressive list of scientists on its Board of Advisors. All of the programs are designed to improve the public's access to scientists, to foster private sponsorship of research, and to inspire interested citizens to get involved.

If you are interested in a working experience (not a guided tour or educational field trip) to share the life of professionals seeking solutions to real problems then contact *Earthwatch, Box 127A, Belmont, Massachusetts 02178* or call (617) 489-3030.

ASC Information Center

The Association of Systematics Collections (ASC) was founded in 1972 in part to meet the need for a single information center to organize and offer information regarding the wealth of available natural history taxonomic resources and services.

Operation of the ASC Information Center was initiated on September 1, 1977. At present, the Center can provide the names and addresses of systematists and systematics collections, as identified by speciality. This information is supplied through the Registry of Taxonomic Resources and Services—a data base developed by the ASC with the support of the USA Energy Research and Development Administration. The Center provides two levels of service. The Fundamental List is a complete listing of those persons or collections that satisfy the stipulations of the inquirer. In the Total Plan, ASC personnel contact each individual identified by the Fundamental List to determine their willingness to participate in a project or problem outlined by an inquirer.

Initially all inquiries will be handled free of charge. Inquiries or requests for more information should be directed to *Rebecca Pyles, ASC Secretariat Office, Museum of Natural History, The University of Kansas, Lawrence, Kansas 66045* or by phone at (913) 864-4867. It is hoped the Center will provide access to the biologists who represent a much needed resource to both science and society.

Request for Information about Leaf-Fall Dates 1950 to 1976

The Ontario Ministry of Natural Resources is involved in a long-term study of White-tailed Deer in northern Frontenac County. Part of this study concerns the effects of autumn weather, including leaf-fall.

In order to supplement existing records, any information regarding leaf-fall dates (80% of deciduous leaves fallen) for eastern Ontario would be greatly appreciated. For each year please give date(s), location(s), and other observations such as principal tree species, and whether leaf-fall had been relatively sudden or gradual.

Please contact Peter Smith, Ontario Ministry of Natural Resources, Fish and Wildlife Research Branch, P.O. Box 50, Maple, Ontario L0J 1E0.

Museum Collections and Canadian Science

From a brief submitted to the Secretary of State of Canada by the Biological Council of Canada

A cardinal tenet of scientific methodology is that reported findings should be subject to later review. In all taxonomic work and in studies such as ecological surveys which depend on the correct identification of the biological organisms examined, it is imperative that the material on which the work was based is maintained for future validification. Because of the incredible diversity of living forms, this essential reassessment of previous work and continued orderly progress in the growth of knowledge is possible only by the use of an international hierarchical system of classification. Communication about the taxonomic groups thus recognized is possible only by adherence to a strict system of nomenclature. Moreover, this system of nomenclature is the key to the data retrieval system enabling results from all types of experiments, observational, analytical, and applied research, to be correlated and compared.

For well over 100 years the desirable practice of designating and preserving voucher specimens resulting from any form of biological research has become common as a documented record of precise taxa to which the data from a particular study pertain.

More recently the designation and preservation of holotype specimens has also been recognized as of central importance in making the nomenclatural classification effective.

To be of value to science, these type and voucher specimens must be preserved indefinitely as permanent reference materials. They are a sacred trust from the 20th century science to future generations. Many intensive and expensive research studies of the past have had their results rendered of questionable value when serious doubt arises about the precise taxa involved. In the absence of voucher specimens, the entire research would have to be duplicated to resolve the validity of published results. Of equal importance, from the point of view of preservation, are large research collections of specimens serving as data-rich "samples" of contemporary populations of living organisms.

The National Botanical and Zoological Collections are presently receiving inadequate financial support, so that some taxonomic groups are completely ignored while others are only minimally served.*

This neglected state of our National Collections is of considerable concern to the Biological Council of Canada, but the situation for other biological collections, presently housed across Canada in provincial or municipal departments and museums, universities, colleges, etc., is already critical. These regional collections receive, for the most part, little federal financial support and have to depend on a variety of other sources for funding. They maintain valuable and representative specimens of the regional fauna and flora of Canada, however, and in some cases have specialized Canadian collections that are as good or better than the designated National Collections. Regional Collections are, therefore, just as much as part of our national heritage as are the National Collections themselves, and are also an essential natural resource serving the interests of the public and the research and study needs of universities and provincial departments of Agriculture, Forestry, Fisheries and Wildlife, etc., as well as being important for epidemiological and ecological studies.

*It is appropriate that the National Museum of Natural Sciences should have primary responsibility for curating type material. This Museum currently has national responsibility for most animal groups both recent and fossil and for all living botanical taxa (except fungi) and some fossil plant groups.

Agriculture Canada also houses the National Collections of fungi, insects, arachnids, mites, as well as a very large botanical herbarium. These, like the National Museum of Natural Sciences, are maintained with scientific curatorial staff of international repute, but of dwindling numbers as vacant positions are not refilled.

Other major Canadian collections include bacteria (National Research Council); freshwater algae (Canada Centre for Inland Waters); and the National Collection of invertebrate fossils and some plant fossils (Geological Survey of Canada).

Because of the scattered nature of these regional collections and the fact that there is no national register of what is being held in such collections, it is presently impossible to make sound recommendations on the steps that must be taken to protect and preserve, for the future, this important part of our national heritage.

The Biological Council of Canada therefore urges that the Secretary of State of Canada establish a Commission of Enquiry with the following objectives:

1. A careful survey and documentation of existing biological collections in Canada, including culture and germplasm depositories;
2. An assessment of their regional, national, and international value as collections;
3. Recommendations for regional resource centers worthy of federal support and specific proposals to ensure the financial stability of such centers in order that they may fulfill their dual function of serving society and science throughout Canada.

Wanted — Sightings of Sandhill Cranes in Northern Ontario

The Greater Sandhill Crane breeds throughout the USA Great Lakes states and in parts of Manitoba. In Northern Ontario (south of 51°N), these birds are considered rare transients but over the past decade have been sighted there with increasing frequency. Sightings of immatures in the last two years have led us to believe that there are Greater Sandhill Cranes breeding in Northern Ontario. We need more reports of sightings to estimate the population distribution and to pick an area of high concentration for a more intensive study of their biology, migration, and taxonomic verification. Please send reports, including the date, location, and number of birds to *Paul Tebbel, Department of Zoology, University of Western Ontario, London, Ontario N6A 5B7.*

IUCN Prepares World Strategy

A document designed to enable international conservation action to be directed much more effectively is now being prepared by IUCN (International Union for Conservation of Nature and Natural Resources).

Called *A World Conservation Strategy,* the document will identify the main ways in which species and ecosystems are depleted, degraded, or destroyed; define effective preventive or remedial action (by governments, intergovernmental bodies, and non-governmental bodies); and propose priorities for action.

The three main functions of the strategy, which is funded by UNEP (United Nations Environmental Program) as part of the IUCN/UNEP ecosystem conservation project, are to provide UNEP, WWF (World Wildlife Fund), and other interested organizations with a global appraisal and action plan for the protection, maintenance, and rational use of the planet's wild living resources; to enable IUCN to decide its program for 1979–1981; and to enable IUCN to advise WWF on the most effective ways of spending funds raised.

A World Conservation Strategy will go into two drafts before being presented for approval by IUCN's 14th General Assembly in late September 1978. Thereafter the strategy will be improved and updated from one general assembly to the next.

By providing for the first time a global perspective on the many problems with which conservation is concerned and a means of ranking the most effective solutions to the priority problems, the strategy should enhance the capacities of IUCN, UNEP, and WWF to initiate action rather than simply to react to ad hoc requests for help.

From IUCN Bulletin New Series 8(10): 59, 1977.

Symposium — Natural Regulation of Wildlife Populations

The Natural Regulation of Wildlife Populations is the theme of a symposium to be held in Vancouver, British Columbia on 10 March 1978. The theme will be discussed for individual species and species' groups by invited persons who have demonstrated through published research a knowledge of the issue. The symposium is part of the annual meeting of the Northwest Section of the Wildlife Society. The regular meeting of the section will be held on the two previous days, 8 and 9 March. For further information please contact F. Bunnell, Faculty of Forestry, University of British Columbia, Vancouver, British Columbia V6T 1W5, or D. Eastman, Fish & Wildlife Branch, Ministry of Recreation and Conservation, Parliament Buildings, Victoria, British Columbia V8W 2Z1.

Wildlife Film Festival

To encourage good wildlife film making, the University of Montana Student Chapter of The Wildlife Society (TWS) is sponsoring a Wildlife Film Festival. Films, all pertaining to wildlife, will be judged by a panel of internationally-recognized film makers. There are two categories, amateur (limited to Montana entries) and North American Professional produced in calendar year 1977. Awards and recognition will be presented. Based on the success of this year's festival, the chapter hopes to host an annual affair.

Information, rules of eligibility, and application forms can be obtained by writing: Wildlife Film Festival, Wildlife Biology Program, University of Montana, Missoula, Montana 59812.

The deadline for submission of applications is 1 March 1978. Qualifying films will be judged and shown on 8-9 April 1978, at the University of Montana.

Annual Meeting of Ontario Ornithologists

The 1978 meeting will be held at the University of Guelph on 18 March 1978. Sessions will be held in Room 113, Physical Sciences Building; the registration fee is $2. Two sessions are planned; 0930 to 1200 h and 1300 to 1700 h.

In the evening Room 168 of the Zoology Building has been reserved for informal gathering and discussion.

For further information please contact Alex L. A. Middleton or Vernon G. Thomas at the Department of Zoology, University of Guelph, Guelph, Ontario N1G 2W1 (telephone 519-824-4120).

Book Reviews

Zoology

Animal Communication

By Hubert and Mable Frings. 1977. Second Edition. University of Oklahoma Press, Norman, Oklahoma. 207 pp., illus. Paper $6.25.

When this book first appeared in 1964 it was greeted with enthusiasm because until then few biological popularists had come to grips with the engrossing subject of communication in animals. Hubert and Mable Frings, both connected with the University of Oklahoma, gathered their data from basic research in behavior, physiology, and ecology, organizing the work along functional lines so that if, for example, one wanted to learn about courtship and mating in mammals (one page), one could readily peruse these subjects in frogs and crabs too. The Frings were modest about their work: "With further knowledge, the provisional organization of communication patterns presented here — even possibly many of the "facts" — will undoubtedly need to be revised or discarded. It is stimulating to realize that impending discoveries may soon render the book itself outdated . . ."

At present, of course, animal communications is recognized as an important field of study occupying the attentions of hundreds of biologists, so that in theory one should welcome a new "revised and enlarged" edition of *Animal Communication.* In fact, however, this edition is a great disappointment. The authors, far from being "stimulated" to realize that the first edition is outdated, have done a complete about-face. They write: "It would be easy . . . to select a different set of examples to illustrate the uses of communication signals by animals. We feel, however, that little would be gained by doing so. The observations of 1964 remain valid in the late 1970's." What is easy was to leave the book as it was and merely add a 16-page chapter on recent research since 1963, which is what the Frings have done. What would have been an effort worth publishing would have been to rewrite the entire book in the light of exciting new discoveries.

Not only is this book sadly dated, but it contains many errors which should have been corrected in a new printing. It is impossible to pinpoint them all since there are no literature citations in the text, and the bibliography, although fairly comprehensive, is of a general nature. For one species with which I am familiar, however, I found gross inaccuracies. The worst was the statement that the male giraffe arouses the female by rubbing his neck along hers — thus necking with her. Necking in giraffe is a behavior pattern confined to males. The Frings claim that giraffe spread alarm by stampeding, giving this as an example of tactile communication. Yet giraffe do not touch each other when alarmed. Finally, they twice make the simplistic statement that the male giraffe determines a female's readiness to mate by tasting her urine. To describe the complex phenomenon of Flehmen in this way is to underestimate badly the interest and capacity of their readers.

Publishers all too often re-issue non-fiction books without making certain they are really up-dated and worth republishing, a habit especially inexcusable in a university press. Worth it or not, the publishers can readvertize the work as something new and special, when in fact it is nothing of the sort. *Animal Communication* was perhaps worth buying in 1964, but I would not recommend this new edition.

Anne Innis Dagg

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A Second Book of Canadian Animals

By Charles Paul May. 1977. Macmillan, Toronto. 109 pp., illus. Paper $4.95.

This 1977 paperback purports to be a new edition of the original 1964 book, but I can find no difference between the two. In any case the text is aimed at a seven- to ten-year-old child, so perhaps no up-dating was necessary. It describes briefly 26 mammals found in Canada, each pleasantly illustrated by John Crosby by a black-and-white pen drawing of an adult and of a juvenile. It is a companion to the 1962 *A book of Canadian animals* by the same author which describes an assortment of 28 different Canadian mammals. Both books are written in a lively manner which should appeal to a thoughtful child.

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Ecology and Management of Animal Resouces, Ecologie de la zone de l'Aéroport International de Montréal

J.R. Bider, E. Thompson, and R.W. Stewart. 1976. Les Presses de l'Université de Montréal, Montréal. 246 pp. $12.

As a title, *Ecology and Management of Animal Resources* is very misleading. It tends to suggest the book is a text on wildlife management which it definitely is not. The subtitle, Ecologie de la Zone de l'Aéroport International de Montréal, clarifies the book's topic somewhat, but not entirely. Basically this book is one in a series of reports all of which are concerned with the Mirabel airport project.

The authors define their objective as "to supply data useful to a broad range of resource developers, including park naturalists as well as architects and land use planners." They define their approach as analytical and intended to "1) qualitatively and quantitatively describe the biotic community; 2) develop a scale of values of parameters which could be used to describe the biotic richness of areas within the community; 3) provide information at the species level." Unfortunately two of the three steps in their approach are not satisfactorily met.

The method of data collection for this study was the sand transect technique developed by the senior author (Bider 1968) and designed to measure animal activity. By the authors' own admission, the technique alone does not provide quantitative data ("Using the sand transect technique we measure the activity of the total population in space and time to be able to predict when, where, and relatively how many sightings might be made regardless of the numbers per unit area"). In the section of the text referring to individual animal species the lack of quantitative data is very apparent and a major weakness of the study. Perhaps trapping could have provided some better information on animal numbers.

The sections dealing with birds are very weak. Granted, the authors state that this is a topic of another separate study; however, they did not indicate in the book's title that this work had been excluded.

Reading through the text one wonders what effort was made to determine how representative the selected site was of the overall area. The authors clearly state "the procedure was to pick out small areas which contained all the major soil types found on the entire airport site and as many vegetation units as possible" and that "the results were used to synthesize a global view of animal activity on the entire expropriated territory." Are we to presume that extrapolation was a straight arithmetic proportion of area sampled versus area expropriated?

Generally speaking if one is looking for a text on animal ecology this book is not recommended. For consultants interested in seeing another approach to animal inventory, the book may be of some interest.

References Cited

Bider, J.R. 1968. Animal activity in uncontrolled terrestrial communities as determined by a sand transect technique. Ecological Monographs 38: 269–308.

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BOTANY

The Vascular Plants of South Dakota

By Theodore van Bruggen. 1976. Iowa State University Press, Ames. 538 pp. Paper $7.95.

Prior to the publication of this book, students interested in the plants of South Dakota had to "make do" with floras of adjacent regions. Now it is possible to identify the 1585 species known from this state, using a single volume.

The book is organized in the fashion of a continuous dichotomous key in which the end of each dichotomy is an expanded species description together with habitat, general locations within the state, flowering time, common names, and necessary synonomy. Students will find the short introduction which outlines the glacial history, geology, physiography, and climate most helpful in understanding the relationships of the flora of this very varied land. The text has been typewritten and has a ragged right-hand margin, two factors which give the volume a somewhat unfinished look, but this does not detract from its usefulness. There are no distribution maps or illustrations, features which might be considered for a future edition.

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Ontario Weeds

By J. F. Alex and C. M. Switzer. 1976. Publication 505, Ontario Ministry of Agriculture and Food, Toronto. 200 pp., 51 colored plates, 184 line drawings. $3.50.

This new edition of *Ontario Weeds* is a completely revised work bearing little resemblance to its predecessors. With an attractively enlarged format (29.5 × 21 cm) it includes reference to almost twice as many weed species as the previous edition. The key has been greatly expanded, a very large number of new drawings have been included, and although there are no longer any black-and-white photographs of seeds and seedlings, eight pages of color plates have been added.

The primary purpose of the book is to allow the user to identify the more widely distributed or important weeds in Ontario. To this end, about 270 of the 500 or so weed species in the province are described and 195 of these are illustrated by black-and-white line drawings. The drawings are of variable quality but nearly always give a realistic impression of the species involved. It is encouraging that it is the new drawings that are of the higher quality, often clearly illustrating features of diagnostic importance. The detail of the characteristic stem and leaf-base structure of the grass family is a particularly good example. On the other hand the new habit drawing of *Veronica peregrina* is hardly an improvement on its predecessor.

As a means of identification the book is not without at least one serious shortcoming. Too often the key ends with the user having to distinguish amongst a large number of possible choices (in one case over 30 species) with no other option than thumbing over the illustrations. The authors, moreover, do not seem very confident about the clarity of their keys, suggesting that users finding difficulty may have to restart "four or five times." In fact the characteristics used are for the most part readily discernible and should not present such severe difficulties even to the beginner.

Errors are not numerous. One is the inclusion of the rather rare *Cynanchum nigrum* (see Pringle 1973, Canadian Field-Naturalist 87: 27–33) with an illustration that appears to be of *C. medium,* the much commoner species of dog-strangling vine in Ontario. The seeds of white cockle and night-flowering catchfly are both oddly described as "grayish-orange"; both are, in fact, black when mature, the former with a gray bloom.

This edition includes reference to giant foxtail (*Setaria faberi* — not *faberii*) with the remark that it "is not known to occur anywhere in Canada at present." Events, however, quickly overtook the authors, for prior to publication the species had already been collected in five separate localities in southern Ontario. Since then *S. faberi* has also been found to be a frequent weed in agricultural areas near Lake St. Clair. This striking demonstration of the constantly changing weed flora of Ontario, as of any other part of the world, makes us look toward future editions of this publication which will be as great an improvement on the present one as it is on its predecessor.

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Vascular Plants of British Columbia—A descriptive resource inventory

By Roy L. Taylor and Bruce MacBryde. 1977. University of British Columbia Botanical Garden Technical Bulletin Number 4. University of British Columbia Press, Vancouver. 754 pp. $28.

Those who, from the title of this book, might have expected a classical flora with keys and descriptions, will be disappointed. This is a rather bulky, soft-covered, computer printout of data which has been gathered on the known vascular flora of British Columbia.

The book is divided into nine sections: (1) introductory material which lists contributors and consultants, a preface, and an introduction, directions on how to use the inventory, and a description of the computer program which was utilized, (2) the inventory, (3) an appendix of standard references, (4) an appendix of miscellaneous references, (5) an appendix of taxon to reference links, (6) an appendix of specific linked references, (7) an appendix of plant name authorities, (8) an example of the data form on which information to be input into the Flora of British Columbia project data base was accumulated, and (9) the index.

The inventory has been divided into four sections: Pteridophyta, Pinophyta, Magnoliophyta–Dicotyledons, and Magnoliophyta–Monocotyledons. Within each of these sections the families, genera, and species are placed in alphabetical sequence. Thus the Asteraceae (Compositae) is found near the beginning of the Dicotyledons rather than at the end as in the Englerian System, which is followed in many floras. Cross references are provided for those searching for Leguminosae so that one might find the required entry under the Fabaceae, and for a genus like *Chrysanthemum* where the species found in the British Columbia flora are treated under *Leucanthemum.*

In order to use the inventory readily, however, the reader must first become familiarized with the abbreviations which have been utilized under the headings of Distribution, Status, Duration, Habit, Sex, Flower Color, Fruit, Fruit Color, Flowering Time, Status of Chromosome Complement in British Columbia, Chromosome Base Number, Chromosome Somatic Number Reported for British Columbia, Poisonous Status, Economic Status, Ornamental Value, and Endangered Status. This, for those who assembled the data, would have been easy, but for the individual who uses the work as an occasional reference it will be most annoying because frequent reference will have to be made to Appendix 6 which is lost at the back of the book, and thus he may turn to the familiar floras of adjacent areas such as *Flora of Alaska* and *Flora of the Pacific Northwest,* rather than tackling this volume.

The authors state that they have attempted to evaluate the taxonomic status of each of the 3137 taxa that are presently known from British Columbia. This was indeed a formidable task. There is, however, no synonomy in the inventory, but for those who are searching for a familiar name not found, they may find a cross reference in the index. In the preface, the authors state that an illustrated, keyed field guide to the plants of British Columbia will be produced by the Botanical Garden of the University of British Columbia, and that later, a several-volume detailed flora will be produced by the British Columbia Provincial Museum.

In the mean time, *Vascular Plants of British Columbia—a descriptive resource inventory,* will help link the areas treated by the *Flora of Alaska* and the *Flora of the Pacific Northwest,* and will serve "as a source of information for the evaluation of the country in relation to its future development and the effective utilization of its natural resources."

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ENVIRONMENT

Ecotours of the Trans-Canada Highway

In 1972, the Canadian Forestry Service introduced a program to provide informative booklets to assist travellers to interpret the ecology of the landscapes along the Trans-Canada Highway. As the first Ecotour, a 20-panel, map-style folder published in 1973 for the Ottawa to North Bay section, met a favorable public response, the project was continued. In 1974, a second Ecotour, covering the Rocky Mountain section from Calgary, Alberta to Golden, British Columbia, was issued as a 20-page booklet, 265 × 165 mm. Since then, as contributions to the Man and the Biosphere Programme/Canada, the Canadian Forestry Service has produced five more Ecotours: for Newfoundland West (1975), Newfoundland East (1975), Nova Scotia (1976), Sault Ste. Marie to North Bay, Ontario (1976), and White River to Sault Ste. Marie, Ontario (1976). These latest are 16-page, full-color booklets, 204 × 228 mm. Ecotours are under production at each of the Canadian Forestry Service's regional forest research centers at Victoria, Edmonton, Sault Ste. Marie, Ste-Foy, Fredericton, and St. John's and at the Petawawa Forest Experiment Station. Eventually Ecotours will be available for the entire Trans-Canada Highway.

The route covered by each Ecotour is divided into major, ecologically distinct, landscape types ("Ecozones"). A map for each Ecozone or section shows the locations of interesting ecological features, which are in most cases identified by code numbers corresponding to those on relevant illustrations and text paragraphs, and the distances between these points of interest. The ecological scope is broad, including diverse features of natural history, both biological and geological, and of human history. Color and monochrome photographs, sketches, and paintings portray plants, animals, fossils, rocks, aerial views, landscapes, people, ships, and buildings. Lists of suggested readings complement most of these well-integrated brochures.

The teams of scientists, writers, photographers, artists, and others that contributed to the production of this series have succeeded admirably in helping travellers understand the flora, fauna, people, scenery, and the forces that have shaped the landscapes they see from their vehicles en route, at selected stops at points of interest, or on suggested detours. They merit much praise for producing attractive and information-packed booklets with very few discrepancies or errors. The scale for the first map in each Newfoundland Ecotour is clearly erroneous, but I noted only a single spelling error in the series. While some might not object to the inappropriate use of

"animals" for mammals, most naturalists would prefer that complete species names be given, e.g., for "partridge (ptarmigan)", as well as for the birds colorfully named locally as "tickle-asses," "stearins," and "sea pigeons" in Newfoundland. Although few or no metric measurements were given in earlier Ecotours, their frequency has been increasing in later numbers, and SI and imperial units have equal prominence in the latest.

The Canadian Forestry Service deserves congratulations for inaugurating this welcome educational series of booklets for Canadian and visiting motorists, or indeed even for readers who stay at home. Unfortunately it seems that many travellers and naturalists, like myself until recently, are unaware of the existence and ready availability of Ecotours.

Although the first Ecotour (Ottawa to North Bay) is out of print, all other numbers mentioned above are available without charge, in either French or English, from: Ecotours, Canadian Forestry Service, Environment Canada, Ottawa, Canada K1A 0E7.

I heartily recommend them to our readers both as prerequisites for planning trips on the Trans-Canada Highway and as indispensable companions en route. Their widespread use before and during trips, or even just at home or school should foster a marked increase in public awareness of the diversity, interest, and beauty of the natural and cultural features across this land.

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A Concrete Look at Nature: Central Park (and other) glimpses

By Eugene Kinkead. 1974. Quadrangle/The New York Times Book Company, New York. xii, 242 pp.

Despite the scoffing of some traditional zoologists, the study of wildlife in a modern urban setting seems to have an assured place at present. In this book, Kinkead writes mainly of Central Park, New York: 840 acres (340 hectares) in central Manhattan.

Whether bird-watching is still a safe pastime in Central Park is perhaps debatable, but in any case the author presents us with a glimpse of its avifauna. In the Preface, he tells us that "each year twelve to twenty species nest there," but no longer the Bobwhite and Wood Duck. In the opening chapter, the bird lists, with commentary, make fairly interesting reading, but "Baltimore oriole," "bronzed grackle," and "English sparrow" are outdated nomenclature.

The next chapter, on meteors, is much more fascinating, with helpful hints on meteor-watching in the city. This topic may be somewhat unexpected in a book on urban nature, but the next essay, on Central Park squirrels, is not. Squirrels are at "an artificially high level here" and quite a challenge to census. Comments on their diet, densities, activity patterns, dens, litter size, and travel routes may be of interest even to the professional mammalogist. In this chapter, Kinkead introduces the only note on reptiles in the book — a brief account of a snake den in Central Park.

Champion-size trees and a city conservation officer are the next two topics. Despite many statistics, the first is a fascinating topic, quite replete with lore and legend, such as the story of "the tree [which] grows in Brooklyn," as well as botanical data such as the effects of air pollution. The second subject I found not quite so interesting, despite vivid accounts of his "beat" in pet shops, restaurants, and other stores.

"Big Rain" (Chapter 6) is again full of figures, but Kinkead does his best with these. The decline of the Eastern Bluebird (Chapter 7) provides an informative if depressing topic; the following one on "Bioluminescence" (for example, of fireflies) is delightful. On the bluebird, the author aptly states "It is, in effect a bird of another era. In the vanished Currier and Ives landscape of an America of long ago . . ." He succinctly presents its status in New York City, along with a number of other highlights of its biology. The fireflies are described as "the pale, soft, disjointed artillery of summer's night," and their biology is also well explained as an amazing but highly technical phenomenon. (Unfortunately not many scientific sources are given.)

Five chapters of uneven interest close *A concrete look at nature*. Kinkead's book is lucidly written, and explanations are generally good. Flaws are minor. The waters of Central Park are cited as 12 in number on p. 228, but several are not shown on the endpaper maps. Other minor faults include some poor choices of common names for plants (e.g., "dogtooth violet,") use of cliches (e.g., "warm climes . . . biting frost . . . lofty reaches," or "critters"), occasional awkward phrasing, and overworked humor. The style contains much charm and some wit, however, so that at its best, it reminds one considerably of Edwin Way Teale's.

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NEW TITLES

Zoology

The American Robin. 1976. By L. Eiserer, Nelson-Hall, Chicago, 175 pp. $12.50.

Analysis of vertebrate populations. 1977. By Graeme Gaughley. Wiley-Interscience, Somerset, New Jersey. 234 pp., illus. $19.95.

A biogeographical analysis of the Chihuahuan Desesrt through its herpetofauna. 1977. By David J. Morafka. Biogeographica. Volume 9. Junk, The Hague. viii + 314 pp., illus. Dfl 95.

The biology of insects. 1977. By C. P. Friedlander. Pica, New York. 189 pp., illus. $12.50.

Birdland: the story of a world famous bird sanctuary. 1976. By Len Hill and Emma Wood. Taplinger, New York. 144 pp., illus. $9.95.

Birdwatcher's guide to wildlife sanctuaries. 1976. By Jessie Kitching. Arco, New York. xv + 233 pp., illus. $8.95.

Butterflies. 1976. By Jo Brewer. Abrams, New York. 176 pp., illus. $18.50.

The courtship of birds. 1977. By Hilda Simon, Dodd, Mead, New York. 190 pp., illus. $12.95.

The evolution of national wildlife law. 1977. By M. J. Bean. United States Government Printing Office, Washington. 485 pp. $4.20.

Fish population dynamics. 1977. Edited by J. A. Gulland. Wily-Interscience, Somerset, New Jersey. 372 pp. $27.

Frogs. 1976. By Michael L. Tyler. Australian Naturalist Library. Collins, London. 256 pp., illus. $17.50.

Handbook of freshwater biology. Volume 2, life history data on centrarchid fishes of the United States and Canada. 1977. By Kenneth D. Carlander. Iowa State University Press, Ames. viii + 432 pp. $18.

Inland fishes of California. 1976. By Peter B. Moyle. University of California Press, Berkeley. 405 pp., illus. $20.

*__An introduction to the aquatic insects of North America.__ 1978. Edited by R. W. Merritt and K. W. Cummins. Kendall/Hall (Canadian distributor Burns and MacEachern, Toronto). Approx. 512 pp., illus. $18.95.

Living new world monkeys (Platyrrhini) with an introduction to primates. Volume 1. 1977. By Philip Hershkovitz. University of Chicago Press, Chicago. 1136 pp., illus. $80.

Manual of neotropical birds. Volume 1. Spheniscidae (penguins) to Laridae (gulls and allies). 1977. By Emmet R. Blake. University of Chicago Press, Chicago. 1674 pp., illus. $50.

Mountain monarchs. Wild sheep and goats of the Himalayas. 1977. By George B. Schaller. University of Chicago Press, Chicago. 432 pp., illus. $25.

The order of wolves. 1976. By Richard Fiennes, Bobbs-Merrill, New York. 206 pp., illus. $13.95.

Sea mammals and reptiles of the Pacific coast. 1976. By Vinson Brown. MacMillan, New York. xvi + 265 pp., illus. $10.95.

Watching birds: an introduction to ornithology. 1977. By R. F. Pasquier. Houghton Mifflin, Boston. 320 pp. $9.95.

Ways of wildlife. 1977. Edited by Eleanor Horwitz. Citation/Scholastic, New York. xvi + 160 pp., illus. Paper $2.95.

Wild birdwatchers I have known. 1977. By Gerry Bennett. G. Bennett, Woodbridge, Ontario. $3.75.

Wildfowl 27. 1976. By G. V. T. Matthews and M. A. Ogilvie. Wildfowl Trust, Slimbridge, England. 176 pp. Paper £2.50.

Wild mammals of New England. 1977. Johns Hopkins University Press (Canadian distributor Burns and MacEachern, Toronto). 336 pp., illus. $30.

Botany

*__Atlas of the flora of the Great Plains.__ 1977. By Great Plains Flora Association. Coordinated by R. L. McGregor. Edited by T. M. Barkley. Iowa State University Press, Ames. 550 pp., illus. $25.

A field guide to Pacific states wildflowers. Field marks of species found in Washington, Oregon, California and adjacent areas. A visual approach arranged by color, form and detail. 1976. By T. F. Niehaus. Illustrated by C. L. Ripper. Peterson Field Guide Series, 22. Houghton Mifflin, Boston.

The forests of the sea: life and death on the continental shelf. 1976. By John L. Culliney. Sierra Club, San Francisco. x + 290 pp., illus. $9.95.

Introduction to the history of mycology. 1976. By G. C. Ainsworth. Cambridge University Press, New York. xi + 359 pp., illus. $27.50.

Medical botany: plants affecting man's health. 1977. By W. H. Lewis and M. P. F. Elvin-Lewis. Willy, New York xviii + 515 pp., illus. $27.50.

*__Orchid biology.__ Reviews and perspectives, 1. 1977. Edited by Joseph Arditti. Cornell University Press, Ithaca. 310 pp. $29.50.

Trees and bushes of Europe. 1976. By O. Polunin. Oxford University Press, New York. xvi + 208 pp. $11.50.

Environment

American environmental history. 1977. By J. M. Petulla. University of California Press, Berkeley. 400 pp. Cloth $15; paper $9.95.

*__Arctic journey.__ Paintings, sketches and reminiscences of a vanishing world. 1977. By Peter Buerschaper. MacMillan, Toronto. 126 pp. $14.95.

Big biology. The US/IBP. 1977. By W. Frank Blair. US/IBP Synthesis Series, Volume 7. Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania. x + 262 pp. $14.95.

Coastal ecosystem management. A technical manual for the conservation of coastal resources. 1977. By John R. Clark. Wiley-Interscience, Somerset, New Jersey. 928 pp., illus. $38.50.

The coastline. A contribution to our understanding of its ecology and physiography in relation to land-use and management and the pressure to which it is subjected. 1977. Edited by R. S. K. Barnes. Wiley-Interscience, Somerset, New Jersey. 356 pp. $28.50.

The cult of the wild. 1977. By B. Rensberger. Drawing by B. Fraser. Anchor/Doubleday, Garden City, New York. viii + 280 pp. $7.95.

Dimensions of ecology. 1977. By J. L. Richardson. Oxford University Press, New York. xiv + 412 pp., illus. $16.

The endless chain of nature: experiment at Hubbard Brook. 1976. By P. P. Sturges. Westminster, Philadelphia. 159 pp., illus. $7.95.

Extinction is forever. Threatened and endangered species of plants in the Americas and their significance in ecosystems today and in the future. 1977. Edited by G. T. Prance and T. S. Elias. Proceedings of a symposium, New York, May 1976. New York Botanical Garden, Bronx. vi+ 438 pp., illus. Paper $20.

Freshwater biology. 1977. By L. G. Willoughby. Pica, New York. 167 pp., illus. $12.50.

†__Fundy tidal power and the environment.__ 1977. Edited by G. R. Daborn. Proceedings of a workshop on the environmental implications of Fundy Tidal Power, Wolfville, Nova Scotia, November 1976. Acadia University Institute Publication Number 28, Wolfville. v + 303 pp., illus. Paper $10 prepaid; $11.50 otherwise.

A guide to nature in winter: northeast and north central North America. 1976. By Donald W. Stokes. Little, Brown, Boston. 374 pp., illus. $8.95.

Mainstreams of biology. 1977. By G. B. Moment and H. M. Habermann. Oxford University Press, New York. xii + 426 pp., illus. $12.95.

Recovery and restoration of damaged ecosystems. 1977. Edited by J. Cairns, Jr., K. L. Dickson, and E. E. Herricks. University of Virginia Press. Charlottesville. 448 pp. $20.

Trails to nature's mysteries: the life of a working naturalist. 1977. By Ross E. Hutchins. Dodd, Mead, New York. 223 pp., illus. $6.95.

Miscellaneous

The collected papers of Charles Darwin. 1977. Edited by Paul H. Barrett. University of Chicago Press, Chicago. Volume 1, xviii + 278 pp., illus; volume 2, viii + 326 pp., illus. Set $40.

Concepts and methods of biostratigraphy. 1977. Edited by E. G. Kauffman and J. E. Hazel. Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania. xiv + 658 pp., illus. $35.

Energy book #2: more natural sources and backyard applications. 1977. Edited by John Prenis. Running Press, Philadelphia. 125 pp., illus. Paper $5.

A fish and vegetable grower for all seasons. 1977. By R. E. Huke and R. W. Sherwin, Jr. Norwich Publications, Norwich, Vermont. iv + 126 pp., illus. Paper $4.95.

*__Forest soils: properties and processes.__ 1977. By K. A. Armson. University of Toronto Press, Toronto. $22.50.

Geomorphology and time. 1977. By J. B. Thornes and D. Brunsden. Halsted (Wiley), New York. xvi + 208 pp., illus. $12.95.

†__Scientists confront Velikovsky.__ 1977. Edited by Donald Goldsmith. Cornell University Press, Ithaca. 183 pp. $8.95.

A vanishing world: the dinosaurs of western Canada. 1977. By Dale W. Russell. Photography by Susanne M. Swibold. Paintings by Eleanor M. Kish. National Museum of Natural Sciences, Ottawa. 144 pp., illus. $12.95.

*__Weather almanac.__ A reference guide to weather, climate and air quality in the United States and its key cities comprising statistics, principles and terminology. 1977. Edited by J. A. Ruffner and F. E. Blair. 2nd edition. Gales, Detroit. 728 pp. $25.

Winter touring: cross-country skiing and snowshoeing. 1977. By Clayne R. Jensen. Burgess, Minneapolis. 163 pp., illus. Paper $7.95.

*assigned for review
†available for review

Instructions to Contributors

Content

The Canadian Field-Naturalist is a medium for publication of original scientific research papers in all fields of natural history that have relevance to Canada. As the journal has a flexible publication policy, items not covered in the traditional sections (Articles, Notes, Letters, News and Comment, and Book Reviews) can be given a special place provided they are judged suitable. Naturalists are also encouraged to support local natural history publications.

Manuscripts

Please submit, in either English or French, three **complete** manuscripts written in the journal style. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants, or minerals.

Type the manuscript on standard-size paper, if possible use paper with numbered lines, double-space throughout, leave generous margins to allow for copy marking, and number each page. For Articles, provide a running head, a bibliographic strip, an abstract, and a list of key words. These items are optional for Notes. Generally words should not be abbreviated but use SI symbols for units of measure. Underline only words meant to appear in italics. The names of authors of scientific names should be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. Authors are encouraged to use "proper" common names (with initial letters capitalized) as long as each species is identified by its scientific name once.

Although we prefer the names of journals in the Literature Cited to be written out in full, these may be abbreviated following the **Bibliographic Guide For Editors & Authors**, The American Chemical Society, Washington, D.C. (1974). Unpublished reports should not be cited here. Next list the captions for figures (numbered in arabic numerals and typed together on a separate page) and present the tables (each titled, numbered consecutively in arabic numerals, and placed on a separate page). Mark in the margin of the text the places for the figures and tables.

Extensive tabular or other supplementary material not essential to the text, typed neatly and headed by the title of the paper and the author's name and address, should be submitted in duplicate on letter-size paper for the Editor to place in the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Canada K1A 0S2. A notation in the published text should state that the material is available, at a nominal charge, from the Depository.

The **CBE Style Manual**, 3rd edition (1972) published by the American Institute of Biological Sciences, is recommended as a guide to contributors. **Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations—Photographs should have a glossy finish and show sharp contrasts. Photographic reproductions of line drawings, no larger than a standard page, are preferable to large originals. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

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Authors must share in the cost of publication by paying $45 for each page in excess of six journal pages, *plus* $5 for each illustration (any size up to a full page), and up to $45 per page for tables (depending on size). Reproduction of color photos is extremely expensive; price quotations may be obtained from the Business Manager. When galley proofs are sent to authors, the journal will solicit on a voluntary basis a commitment, especially if grant or institutional funds are available, to pay $45 per page for all published pages. Authors may also be charged for their changes in proofs.

Limited journal funds are available to help offset publication charges to authors with minimal financial resources. Requests for financial assistance should be made to the Editor when the manuscript is submitted.

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Reviewing Policy of *The Canadian Field-Naturalist*

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it himself or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. The Editor makes the final decision on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality and overall high standards of the journal.

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Cover: Woodchuck photographed 17 August 1965 by Donald A. Smith, on Carleton University campus, Ottawa, Ontario. See article on page 128.

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Changes in Aspen Parkland Habitats Bordering Alberta Sloughs

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Aspen parkland habitats within 50 m of 913 sloughs in 74 quarter sections throughout Alberta's aspen parkland were mapped in the field and a subsample of 398 sloughs was compared with 1945–1949 airphotos. Between 1945–1949 and 1974 woody borders were reduced around 80% of sloughs in the subsample and eliminated completely from 32%. The average loss of border habitats was 1.0 ha per slough or 11.7 ha per quarter section. Average losses per slough were 32% of young aspen, 9% of older aspen, 68% of willows, and 74% of Wolf Willow, Buckbrush, and other shrubs taken together. These are net losses and are not explainable by maturation. The modal index of heterogeneity of habitats bordering sloughs was low throughout the parkland, and in some areas few sloughs had even moderate border heterogeneity. Existing heterogeneity and recent changes in slough border habitats both are strongly influenced by agricultural practices. Changes reported here have altered the basic nature of the habitat mosaic of Alberta's aspen parkland.

Key Words: agriculture, Alberta, aspen parkland, heterogeneity, sloughs, waterfowl.

Aspen parkland developed as an irregular mosaic of aspen groves and Rough Fescue parks mainly on poorly drained till between the mixed prairie and the boreal forest.

The parkland and its sloughs have been valuable habitats for many wild species, plant and animal, game and non-game (Bird 1961; Bird and Bird 1967). A particularly large proportion of North American ducks is produced in habitats associated with parkland sloughs. During dry years, the more stable water area of the parkland accommodates a reserve of breeding waterfowl that stabilizes prairie duck production (Stoudt 1971).

The aspen parkland is young and dynamic (Bailey and Wroe 1974; Kiel et al. 1972; Johnston and Smoliak 1968; Bird 1961) but its historical development is not fully understood (Coupland 1950; Hansen 1949; Moss and Campbell 1947). The clonal reproduction of aspen (Horton and Maini 1964) clearly was an important factor throughout the history of the parkland. Fire (Bailey and Wroe 1974; Bird 1930, 1961; Moss 1932) and mechanical disturbances (Roe 1939) may have been important at particular times. Recent technological and economic changes have made agriculture a major force of change in the parkland. Changes in the parkland probably were most rapid during the period of settlement after World War I but the changes during the quarter century after World War II were both extensive and intense (Kiel et al. 1972; Lodge 1969; Bird 1961) (see Figure 1).

About a quarter century ago the aspen parkland occupied about 222 000 km^2 of which about 52 000 km^2 were in Alberta (Moss 1932; Moss and Campbell 1947). The area of Alberta parkland has been changed substantially by agricultural development within the parkland mosaic. Lodge (1969) reported that about 1000 km^2 per year within the Alberta parkland was being removed just for conversion to improved pasture. These figures suggest that the parkland is still subject to important changes but there is little knowledge of the extent, nature or

FIGURE 1. Much of the Central parkland is now an agricultural mosaic composed of quarter sections under diverse land management.

rate of recent changes to aspen groves and habitats bordering parkland sloughs. The present study was undertaken to assess changes that have taken place in slough borders since World War II and to provide baseline descriptions against which future changes can be measured.

Methods

Study Area

Seventy-four quarter sections, each 64.75 ha (or 0.5 × 0.5 mi), were selected from 200 quarters previously chosen randomly from Alberta's black soil zone by Goodman and Pryor (undated. A preliminary study of the methods and rates of alteration of waterfowl habitat in the black soil zone of western Canada. Unpublished report, Canadian Wildlife Service, Edmonton, Alberta, 55 pp.). These 74 quarter sections met two criteria: (1) they had more than one slough, and (2) they were photographed from the air during the 1970 study. The majority of 913 sloughs studied were less than 0.2 ha (0.5 acres), over 700 were less than 0.4 ha, and only a few exceeded 2 ha (5 acres) but large sloughs were not excluded from the sample. Figure 2 shows the distribution of this sample throughout the Alberta aspen parkland.

Field Mapping

A base map was prepared for each quarter section from vertical airphotos, 5.7 × 5.7 cm, taken in the 1970 study. Negatives of those photographs were enlarged optically onto graph paper (25 × 25 cm) to a scale of 1:3706. All important landmarks, vegetation, and land use boundaries and slough features, as they appeared in 1970, were traced from the projected

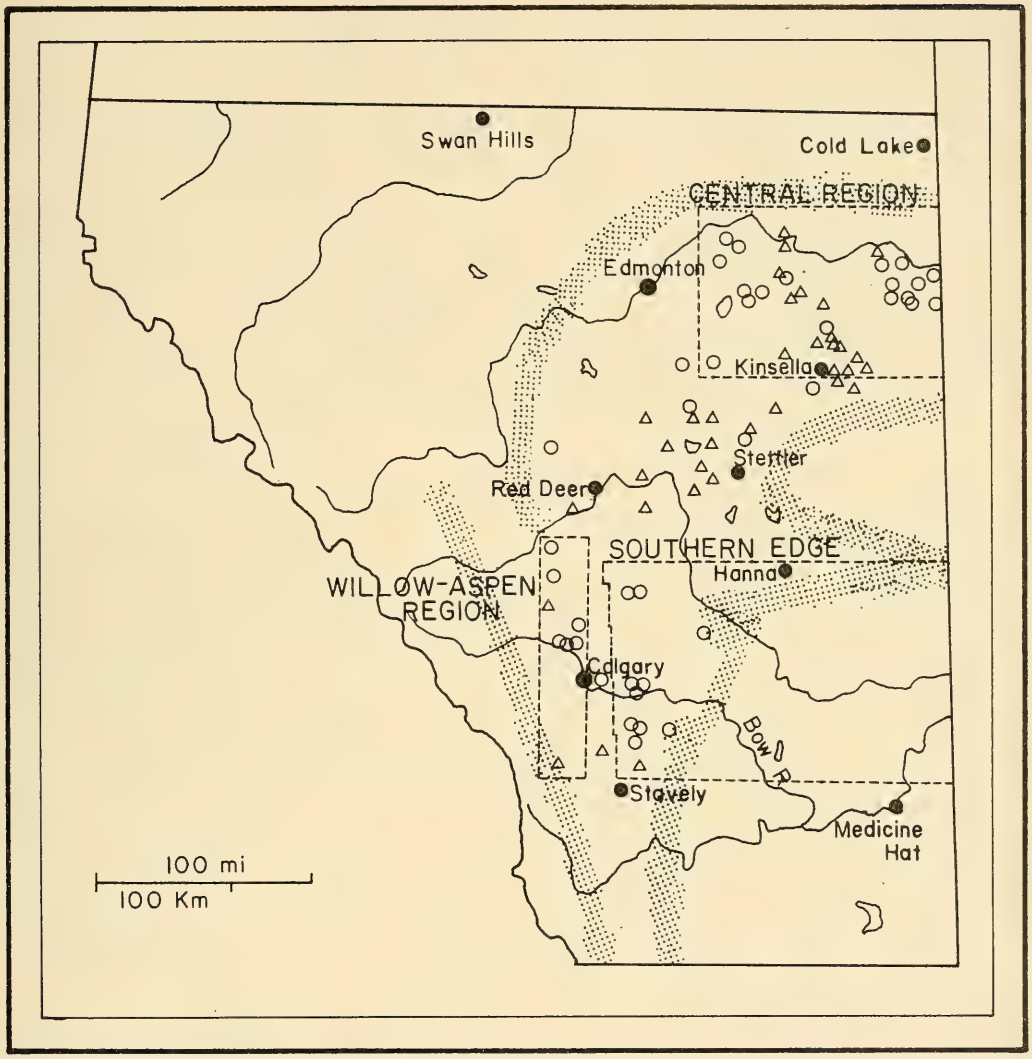

FIGURE 2. Distribution of 74 quarter sections studied in the field (circles and triangles) and those also studied from 1945–1949 airphotos (triangles only). Boundaries for three regional subsamples and approximate limits of Alberta parkland also are shown.

image onto 1-mm graph paper. These base maps were used in the field to map vegetation and land use boundaries at 1 mm = 3.7 m and to note changes since 1970. Figure 3 is an example of a completed field map.

Vegetation Types

Major vegetation types within 50 m of the edge of each slough were mapped to characterize the habitats bordering the sloughs. Woody vegetation bordering sloughs was usually dominated by Trembling Aspen (*Populus tremuloides*). *Populus balsamifera balsamifera* and ssp. *trichocarpa* (Brayshaw 1965) are not separated from *P. tremuloides*.

Findings of Maini (1960) and Horton and Maini (1964) suggested that growth, senescence, and rejuvenation of aspen groves are not usually strict functions of age or of diameter (evident also in definitions, below). A classification of stand maturity was devised to give useful inventories of existing habitat conditions in slough borders. Four aspen maturity classes were used: (1) PO IV, overmature stands with

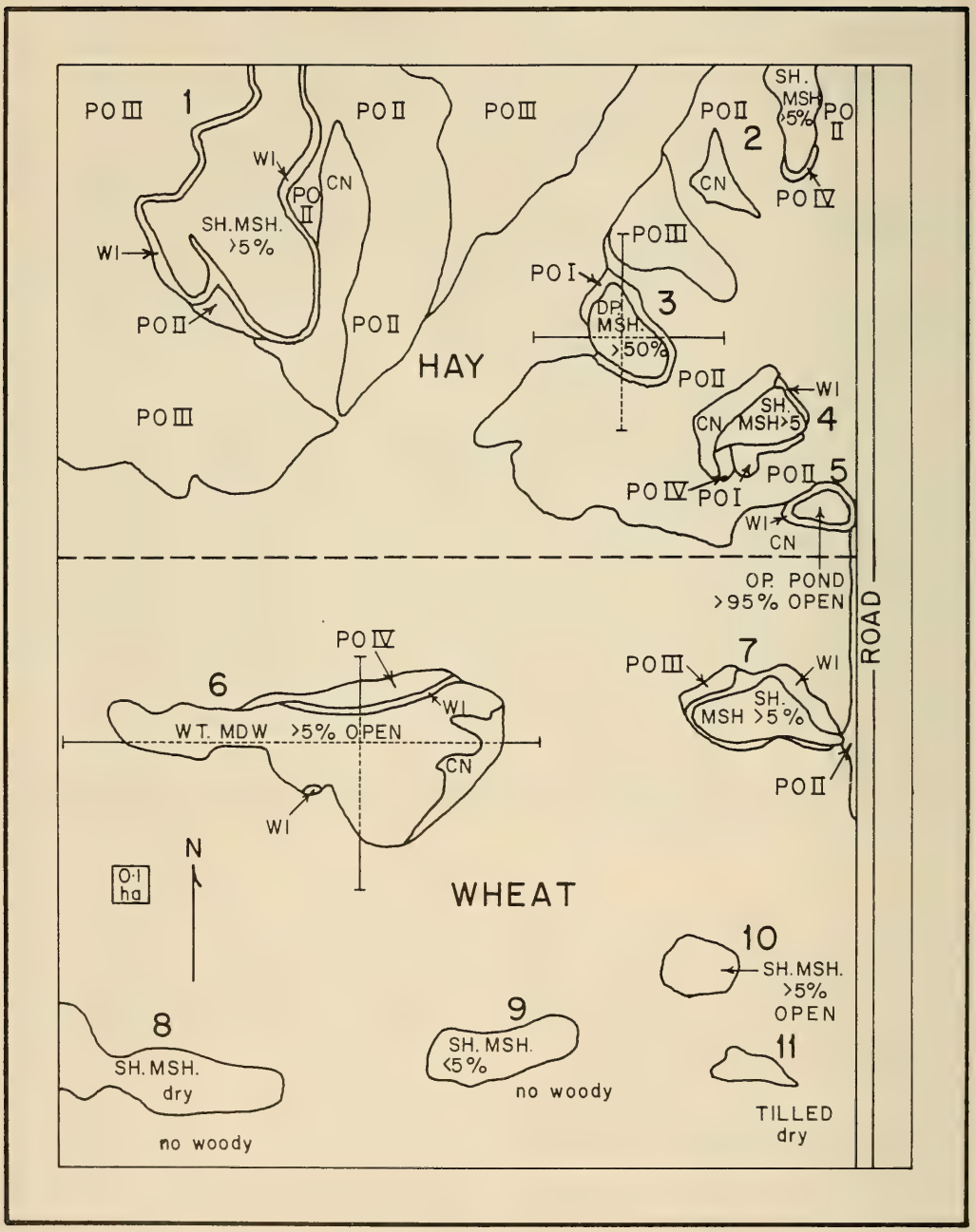

FIGURE 3. Composite map of part of a quarter section to illustrate methods of field mapping and indexing heterogeneity. Slough types: shallow marsh, deep marsh, wet meadow, and percent open water area. Vegetation: PO I, PO II, PO III, PO IV — aspen maturity classes; Wi — willows; CN — natural clearing. Coarse dashed line, land-use boundary. Transects for indexing heterogeneity are drawn on sloughs 3 and 6. On slough 3, the N, W, S, and E transects score 3, 1, 2, and 2 for 50 m out from water's edge (solid line). For slough 6 the scores are 3, 1, 1, and 2 in the same order. The heterogeneity index is 8 for slough 3, and 7 for slough 6.

butt rot or rotting and falling limbs or tops, diameter at breast height (dbh) > 12 cm, averaging > 19 cm, ages > 32 yr, averaging > 50; (2) PO III, prime maturity, dbh > 5 cm, averaging near 11 cm, ages > 16 yr, averaging > 26 yr; (3) PO II, immature, dbh > 3 cm, averaging > 5 cm, usually > 6 yr, averaging near 12; (4) PO I, suckers or saplings up to 3 m tall or 3 cm dbh. Dead aspen also was recorded in these classes. These maturity classes were assigned by visual inspection during field mapping; ages and diameters were not measured on mapped stands. Defining measurements given above were taken from 130 trees in representative stands.

Willows (*Salix* spp.) were common in slough borders. They were mapped and noted as live or dead but not designated by species.

Upland shrubs that were mapped for 50 m back from every slough were Wolf Willow (*Elaeagnus commutata*), Buckbrush (*Symphoricarpos occidentalis*), roses (*Rosa* spp), raspberries (*Rubus* spp.), and Saskatoons (*Amelanchier alnifolia*). These five species (hereafter called "shrubs") were analyzed as a group. Adjacent agricultural land use also was mapped. Plant names follow Moss (1959).

Slough Types and Sizes

Aquatic and semi-aquatic vegetation was not mapped but was the basis for the classification of each slough. Six slough types were recognized (see, for example, Figure 3) (cf., Stewart and Kantrud 1969, 1971): (1) Tilled — cultivated or hay or grain; (2) Low Prairie — all grasses and forbs with no semi-aquatics or sedges, may have been tilled previously; (3) Wet Meadow — grasses and sedges, central portion may be dominated by semi-aquatics, may have been tilled previously; (4) Shallow Marsh — few or no grasses in central portion, sedges usually important, *Polygonum, Eleocharis, Juncus, Sium, Ranunculus, Alisma,* or *Sparganium* usually among the emergents, *Lemna* and *Utricularia* often in open water; (5) Deep Marsh — sedges not important in deepest portion, *Typha* or *Scirpus* often present, *Potomageton, Ceratophyllum, Myriophyllum, Utricularia, Ranunculus* may be present in open water; (6) Open Pond — not characterized by vegetation, usually 0 to 5% cover. Low prairies and wet meadows were divided into wet or dry. Marshes were subclassed by area of open water into dry, < 5%, 5% to 50%, 50% to 95% or > 95%.

Boundaries of tilled sloughs, low prairies, and wet meadows followed the poorly drained basin as indicated by vegetation types. Boundaries of sloughs with woody borders were drawn through the willow ring. When lacking woody borders, the shallow marshes, deep marshes, and open ponds were bounded through the zone of semi-aquatic vegetation with reference to topography and drainage changes. Water levels were abnormally high in 1974 and often exceeded slough boundaries. Slough sizes were measured from field maps by dot grid planimeter.

Habitat Heterogeneity

A heterogeneity index was devised to summarize the mapped descriptions of habitats bordering the sloughs and to permit their quantitative comparison. Crossed transects were laid over each slough on the field maps with four arms radiating N, S, E, and W for 50 m from the slough edge (see Figure 3). These arms were treated as four separate transects. Each mapped vegetation type, land-use type or adjacent slough cut by each transect was recorded in order from slough edge to transect end. Thus transect N described the S-facing slough border, etc. If a transect went off the quarter section before it reached 50 m from the slough, its record was terminated with "off quarter" and excluded from the analysis.

Total number of occurrences of vegetation types, land-use types, and adjacent sloughs intercepted by each of the four transect arms was used to index the heterogeneity of habitats around each slough. Dead woody vegetation was included with live of the same type. If a habitat type repeated itself along a transect arm, say as habitats 1 and 3 in a sequence, it scored twice. The mean of the scores for the transect arms that did not go "off quarter" was the heterogeneity index for that slough. For sloughs that were not on the quarter section boundary, an index of 1 would mean one habitat type on each transect arm, an index of 2 would mean two habitat types on each transect arm or five on one arm and one on each of three others, etc. The heterogeneity index can be subdivided to show how much of the heterogeneity was due to (1) woody vegetation (aspen + willows), (2) natural habitats (woody vegetation + shrubs and

roses + non-agricultural clearings + any adjacent sloughs), and (3) agricultural land uses.

Slough borders also were characterized by the degree to which the aspen or willow border (not "shrubs") encircled each slough. This was indexed by counting the number of transect arms which crossed aspen or willow habitats provided only that the vegetation units actually were connected together to form a slough border. These index values were grouped into Smith's (1971) original classes. Class 1 ("open") had scores of 0 or 1, class 2 ("half closed") scored 2, and class 3 ("closed") scored 3 or 4.

Regional Comparison

After field work was completed, in order to compare different types of parkland, three regions were defined as shown in Figure 2. These are "Central" (West of Meridian (M) 4, Township (T) $>$ 45, Range (R) $<$ 19), "Southern Edge" (M = 4, T $<$ 32, R $<$ 28), and "Willow-Aspen" (M = 5, T $\leq$ 34, R $<$ 5). Regions were defined to show whether these subsamples contained different types of habitats associated with the sloughs. Therefore regional samples were defined to fall clearly within each region and to avoid the boundaries. Consequently some sloughs that are included in the total sample of 913 are not included in the total of these regional samples (655). The total sample (913) is used wherever possible but regional samples are used for comparisons that demonstrate regional differences in woody slough borders.

Habitat Changes 1945–1949 to 1974

Airphotos were available from 1945–1949 for 398 sloughs which had woody borders then and also were studied in 1974. Data from these airphotos were compared with 1974 field data for the same sloughs to measure changes in vegetation during the 25 to 29 years following World War II. This sample was defined solely by the availability of airphotos from 1945–1949 at 1:15840 scale, and the resulting sample distribution means that changes revealed by this comparison apply primarily to the area north of Hanna (Figure 2).

Data for 1945–1949 were obtained by airphoto interpretation. Vegetation types were (a) PO I and II, (b) PO III and IV, (c) willows, (d) Wolf Willow, Buckbrush, and roses. Grouping into these more inclusive categories reduced the chance of interpretation error and still gave satisfactory comparisons with 1974 data. Interpretation of these vegetation types was based on crown diameter, height, texture, and tone. Since both aspen types usually appeared on every photo, their interpretation also was comparative.

Areas of each vegetation type were measured by dot grid planimeters. One was scaled for the 1945–1949 airphotos, the other for the 1974 maps. Both measured in units of 0.16 ha (0.395 acres).

Some factors causing change in parkland slough borders also were evaluated. Clearing of aspen or willow since 1970 was recorded in the field and by comparing 1970 photos with 1974 field maps. Clearing was recorded as extensive (large areas bulldozed or many slough borders totally removed), or minor (fence lines bulldozed or a few slough borders trimmed back), or moderate if between these extremes. Use of herbicide for clearing was recorded similarly. Agricultural intensity was rated in five classes for each quarter section. Intensity ratings were based on amount, type, and distribution of machinery, livestock, woody and weedy vegetation, and tillage. Other developments, such as gas or oil rigs and lines, roads, buildings, drainage and filling operations were recorded where they affected sloughs or their borders.

Results

Distribution and Abundance of Slough Types

The abundance of all slough types in each region of Alberta parkland and in the total sample is given in Table 1. Tilled sloughs are uncommon in the Willow-Aspen because it is primarily rangeland; they are most common in the Southern Edge owing to intensive agriculture and easily tilled slough types. Wet meadows and low prairies are most common in the Southern Edge and Willow-Aspen but these areas were nearly all dry in 1974, and in those same regions shallow marshes commonly had less than 5% open water (more than 95% vegetative cover). Open ponds and deep marshes were much less frequent in the Southern Edge and the Willow-Aspen.

Table 2 reduces the slough types to five so that their occurrence in five size classes can be examined by region. Deep marshes (Central

TABLE 1—Frequency distribution of slough types for all sloughs[1] examined and for three parkland regions[2]

Slough type (vegetation, open water)	All sloughs, no. (%)	Central, no. (%)	Southern Edge, no. (%)	Willow-aspen, no. (%)
Open pond	64(7.0)	27(5.8)	3(3.2)	3(3.0)
Deep marsh, > 95%	22(2.4)	5(1.1)	0(0)	0(0)
Deep marsh, > 50%	50(5.5)	37(8.0)	0(0)	0(0)
Deep marsh, > 5%	46(5.0)	28(6.1)	1(1.1)	0(0)
Deep marsh, dry	4(0.4)	3(0.6)	0(0)	0(0)
Shallow marsh, > 95%	18(2.0)	6(1.3)	0(0)	0(0)
Shallow marsh, >50%	71(7.8)	48(10.4)	1(1.1)	6(6.1)
Shallow marsh, > 5%	101(11.1)	69(14.9)	3(3.2)	5(5.1)
Shallow marsh, < 5%	165(18.1)	107(23.2)	1(1.1)	13(13.1)
Shallow marsh, dry	52(5.7)	10(2.2)	6(6.4)	9(9.1)
Wet meadow, wet	23(2.5)	17(3.7)	1(1.1)	0(0)
Wet meadow, dry	176(19.3)	60(13.0)	34(36.1)	49(49.5)
Low prairie, wet	3(0.3)	2(0.4)	0(0)	1(1.0)
Low prairie, dry	33(3.6)	2(0.4)	15(15.9)	10(10.1)
Tilled	85(9.3)	41(8.9)	29(30.8)	3(3.0)
Totals	913	462	94	99

[1]Total sample of 913 sloughs from the whole Alberta parkland.
[2]These subsamples, totalling 655 of the 913 sloughs, represent each region of the Alberta parkland. The regions are considered natural but they were defined here by political (linear) boundaries. Consequently 258 sloughs are excluded from the regional subsamples but included in the total sample (see Figure 1).

region) formed 6% of the smallest class and were less common as size increased. Small shallow marshes are the commonest slough type in the Central region and become less common as size increases. Wet meadows and low prairies are the commonest slough types in Southern Edge and

TABLE 2—Regional distribution of slough types in five size classes expressed as percentage of all sloughs in each region and total number of sloughs of each size by region. A—all sloughs, C—Central Parkland, SE—Southern Edge, WA—Willow-Aspen (see Figure 1).

Size class	Region	Open pond	Deep marsh	Shallow marsh	Low prairie and wet meadow	Tilled	Number of sloughs
0.04–0.20 ha	A	1.5	4.5	27.0	18.9	7.4	543
(0.1–0.5 ac)	C	1.5	5.8	33.3	14.1	6.7	284
	SE	2.1	1.1	3.2	28.7	24.5	56
	WA	0	0	15.2	50.5	3.0	68
0.21–0.42 ha	A	1.9	3.9	10.6	4.3	1.2	200
(0.6–1.0 ac)	C	1.1	3.9	12.8	1.5	1.3	95
	SE	1.1	0	5.3	17.0	4.2	26
	WA	1.0	0	5.0	9.1	0	15
0.43–0.82 ha	A	1.2	2.3	3.7	2.1	< 1	90
(1.1–2.0 ac)	C	1.5	3.0	3.0	1.7	< 1	47
	SE	0	0	2.1	6.4	1.1	9
	WA	1.0	0	7.1	1.0	0	9
0.83–2.02 ha	A	1.4	1.4	2.3	< 1	< 1	52
(2.1–5.0 ac)	C	1.1	1.7	1.5	< 1	0	21
	SE	0	0	0	1.1	1.1	2
	WA	0	0	6.1	0	0	6
> 2.2 ha	A	< 1	1.2	< 1	0	0	28
(> 5.0 ac)	C	< 1	1.3	1.3	0	0	15
	SE	0	0	1.1	0	0	1
	WA	1.0	0	0	0	0	1

Willow-Aspen. They also become less common as size increases and are rare above 0.82 ha. Tilled sloughs were uncommon above the two smallest sizes (0.42 ha) and tilled sloughs were three times as frequent in the Southern Edge as anywhere else.

The modal heterogeneity index (see Methods) of 1.0 for all regions in Table 3 means that only one vegetation type or land-use type was found on each transect through a slough (Figure 3). The percentage of index values > 2.0 is a measure of the commonness of slough borders having the equivalent of two vegetation types or one vegetation type and one land-use type on each transect. Alternatively, a value of 2.0 could mean three different vegetation types on each of two transects and one land use on each of two others. The Southern Edge has only 1% of sloughs above an index of 2.0 compared to 29% for the Willow-Aspen, 36% for the Central region, and 27% for all sloughs.

Wolf Willow, Buckbrush, and roses form preferred nest sites for Mallards (*Anas platyrhynchos*) and are common nest sites for other species in the parkland (Smith 1971). For all sloughs studied and for Central parkland sloughs, these shrubs were found commonly within 50 m of sloughs only if the heterogeneity index was above 1.75.

Table 4 shows that total heterogeneity exceeded agricultural heterogeneity in only a little over half of all sloughs. In other words, in nearly half the sloughs, agricultural crops accounted for all the heterogeneity indexed! This relationship is extreme in the Southern Edge where crops constituted all the heterogeneity for over 94% of the sloughs. In the Central and Willow-Aspen regions over 30% of sloughs had heterogeneity due to vegetation other than agricultural crops.

The difference between total heterogeneity and agricultural heterogenity was due to natural components (woody, clearings, other sloughs). This natural heterogeneity equalled or exceeded agricultural heterogeneity in over 30% of all sloughs studied except those in the Southern Edge.

Where natural heterogeneity exceeded woody heterogeneity, the excess was due to natural clearings or neighboring sloughs. These natural

TABLE 3—Frequency distribution of mean heterogeneity index values[1] for all sloughs and for sloughs in each study region of Alberta

Total heterogeneity index	All sloughs	Central	Southern Edge	Willow-Aspen
1.00	359	147	87	28
1.25	81	50	0	5
1.33	24	9	3	4
1.50	55	32	0	6
1.67	29	13	1	6
1.75	52	17	0	12
2.00	63	29	2	9
2.25	46	26	1	5
2.33	22	12	0	6
2.50	40	28	0	3
2.67	20	14	0	1
2.75	32	22	0	5
3.00	44	27	0	5
3.25	14	9	0	1
3.33	6	3	0	2
3.50	9	9	0	0
3.67	5	5	0	0
3.75	4	4	0	0
4.00	6	4	0	1
4.25	1	1	0	0
4.33	1	1	0	0
Number of sloughs	913	462	94	99

[1]Defined in Methods.

TABLE 4—Regional comparison of heterogeneity of slough borders as shown by components of heterogeneity, absence of particular vegetation types, and the completeness of the ring of woody vegetation

	Percentage frequencies			
	All sloughs	Central	Southern Edge	Willow-Aspen
Total heterogeneity[1] > agricultural heterogeneity	56.6[2]	64.9	5.3	68.7
Natural heterogeneity ≥ agricultural heterogeneity	34.1	40.3	4.3	32.3
Natural heterogeneity > woody heterogeneity	26.1	34.5	0.0	19.2
Aspen and willow absent	43.8	43.3	93.6	37.4
Shrub vegetation[3] absent	92.4	90.3	100.0	90.9
Aspen, willow, and shrub absent	48.1	43.3	93.6	31.3
Woody border Class 1 (open)[4]	58.4	53.3	94.7	40.4
Class 2 (half closed)	8.8	6.9	2.1	17.2
Class 3 (closed)	32.8	39.8	3.2	37.4

[1]Heterogeneity components defined in Methods.
[2]No categories are mutually exclusive, percentages will not sum to 100 except for the three classes of woody border.
[3]Wolf Willow and/or Buckbrush and/or roses and/or raspberries and/or Saskatoons.
[4]The degree of completeness of the woody border around sloughs. Class 1 means a quarter ring or less of continuous border, class 2 means .25 to .75 of the perimeter is continuously bordered, class 3 means from .75 to a complete ring (see Methods).

sources of heterogeneity were most frequent (34%) in the Central region, much less frequent (19%) in Willow-Aspen, and totally absent from the sample in the Southern Edge. Slough densities are lower there and natural clearings are no longer common.

The percentage of sloughs that lacked aspen and willow was very high in the Southern Edge (93%, Table 4) and no sloughs in that region had the three shrub species. The combined absence of woody and "shrub" vegetation is much less common in the Willow-Aspen region because willow is so widespread.

Woody border classes index the continuity of aspen and willow on the slough perimeter. Sloughs tend to be either open or closed except in the Willow-Aspen region where half-closed borders are more common (Table 4). In other regions and especially in the Southern Edge, open borders predominate. Smith (1971) showed that Mallards and Lesser Scaup (*Athya affinis*) preferred half-closed borders, Blue-winged Teal (*Anas discors*) preferred open, and American Wigeon (*Mareca americana*) preferred closed.

Forces Changing Slough Borders

In 1974 dead and dying aspen and willow were frequent components of slough borders because of two years of continuous inundation. Some plants leafed out again in 1974 but failed by July and were totally dead by August or September. Some had died in 1973 and already were dropping woody material into the sloughs.

Dead willow was recorded 65 times on transects on 29 sloughs in 13 quarter sections mainly in the Central region. Dead aspen occurred 64 times on transects through 34 sloughs on 13 quarters. In most cases, if water levels killed willow, aspen also was killed. Generally the killed aspen was in the two immature classes. But mature trees certainly were not immune.

Clearing of aspens and/or willows for agricultural purposes from 1970 to 1974 was observed on 17 of 74 quarter sections (23%). Of the 17, 8 had extensive clearing, 8 had little clearing, and only 1 had moderate clearing. Six of the 8 with extensive clearing also were subject to very intensive agriculture. The 8 with little clearing showed no clear relationship with agricultural intensity. These results suggest that extensive clearing often is associated with intensive agriculture. It also seems that clearing usually was either extensive or minor and seldom moderate. Discussions with farmers indicated that amount of clearing depends more on availability of capital than on land-use considerations. Marginal farming operations can fund aspen clearing with heavy equipment less frequently and to lesser extents. Extensive clearing, however, does occur on marginal lands,

very often with no agricultural follow-up and consequent aspen regrowth.

"Developments" other than agriculture were not frequent individually but together they affected 14 of the 74 quarter sections sampled. Usually these were not the same quarters subject to intense agriculture so that these "developments" additively increase the potential impact on wildlife habitat. The number of quarters on which various developments occurred were ditching and dugout ponds, 3; gas lines, wells and flares, 3; gravel pits, 1; housing, 3; municipal dump, 1; oil rigs and wells, 1; power lines, 2.

Only one successful removal of a slough by drainage was noted but water levels were so high in 1974 that much slough drainage in the parkland was not observable. Filling of sloughs with soil for agricultural purposes was noted only once. Filling with trash, car bodies, etc. is all too common. Although death or damage to woody vegetation by herbicide was observed frequently away from sloughs, records do not indicate that use of herbicide was a major controller of woody vegetation around sloughs. This does not reduce the possibility that herbicides may enter sloughs and significantly affect them in other ways.

In addition to these particular forces slough borders are shaped by the major, but poorly-defined forces of successional maturation.

Changes in Slough Borders 1945–1949 to 1974

Table 5 summarizes changes in the woody vegetation types for a subsample of sloughs studied in the field in 1974 and for which airphotos taken between 1945 and 1949 were available. Measurements of changes in vegetation during the 25- to 29-year interval are described in Methods.

Immature aspen decreased around 85% of the sloughs and mature aspen decreased around 59% of them. PO I/II decreased around 250 sloughs but less than half of those changes can be explained by aspen maturation because only 102 sloughs had an increase in PO III/IV. The sloughs with no change are approximately balanced between PO I/II and PO III/IV and can be assumed to indicate stable replacement in those few cases. If 102 of the decreases in PO I/II are explained by the number of increases in PO III/IV, then a minimum of 148 decreases in PO I/II are not explained by maturation. A maximum of 30 of the 183 decreases in PO III/IV could be cancelled by the 30 increases in PO I/II. These remaining decreases in both maturity classes are not explainable by maturation and indicate a lack of stable replacement. This also is shown by the mean net losses per slough of 32% of young aspen and 9% of older aspen. The mean net losses of the two aspen classes underestimates the importance of aspen losses from around many sloughs spread widely through the study area and overestimates losses for a few areas in the central parkland with large numbers of sloughs and large net gains in aspen.

Willows increased around 22% of the sloughs (Table 5) in those quarter sections where water levels and land management permitted, but willows decreased much more than they gained. Of the 209 decreases in Table 5, only 29 were caused by high water in 1972–1974; apparently losses have continued for a long time. Even over a quarter century, a mean net loss of 0.22 ha (0.66 acres) or 68% of the willow area around

TABLE 5—Changes in area of major vegetation types within 50 m of 398 sloughs from 1945–1949 to 1974

	PO I/II[1]	PO III/IV[1]	Willow[2]	Shrub[3]
No. sloughs with increase	30	102	61	17
No. sloughs with no change[4]	16	23	10	5
No. sloughs with decrease	250	183	209	161
$\bar{x}$ hectares per slough 1945–1949[5]	1.53	1.78	0.32	0.23
$\bar{x}$ hectares net change per slough	−0.48	−0.16	−0.22	−0.17
$\bar{x}$ % loss of area per slough	32	9	68	74

[1]PO I — aspen saplings or suckers, PO II — growing immature aspen, PO III — prime mature aspen, PO IV — overmature aspen (see Methods for definitions).
[2]Willow (*Salix* spp.).
[3]As defined in Table 4.
[4]Sloughs were excluded from consideration if the vegetation type was absent in both 1945–1949 and 1974.
[5]Variable sample size (See [4]).

TABLE 6—Changes from 1945–1949 to 1974 in total area of all major woody vegetation in borders of 398 sloughs in 35 quarter sections[1]

	Quarter sections	Sloughs
No. with no net change	2	15
No. with net increase	3	62
No. with net decrease	30	321
$\bar{x}$ net change (ha)	−11.7	−1.0
$\bar{x}$ loss (% 1945–1949 area)	55.7	55.7

[1]Complete data available from Canadian Wildlife Service, Western Region, Edmonton, or from the author.

each slough, is a striking reduction.

"Shrub" vegetation decreased in area around 90% of sloughs and increased around only 9% of them. The average loss of 0.17 ha (0.43 acres) or 74% of the 1945–1949 shrub area within 50 m of these sloughs is another massive habitat change.

Table 6 summarizes the changes shown in Table 5 by quarter sections and by sloughs with no distinction of border vegetation types. There was a net decrease in woody vegetation within 50 m of sloughs in 86% of the quarter sections while only 9% had an increase. Vegetation types recorded here decreased on 80% of the sloughs and increased on only 15% which are located mainly on a small number of quarter sections with high densities of sloughs in the Central region. The net loss of four major vegetation types around 398 sloughs amounted to 413 ha (1020 acres) over about three decades.

Records of total removal of woody borders by 1974 from sloughs which had woody borders in 1945–1949 give another view of clearing. Woody borders were totally eliminated from 126 out of 398 sloughs compared (on 21 of 35 quarter sections). Three of the 35 quarters lost all woody borders from over 75% of woody-bordered sloughs, 8 lost all woody borders from 50 to 75%, and 5 lost them from 25 to 50%. Only 8 sloughs gained new woody borders between 1945–1949 and 1974 and most of those were simple willow rings.

A minimum estimate of the dynamics of woody vegetation within 50 m of slough margins during this period of 25 to 29 years can be given by adding total decreases in area to total increases in area for each of the four vegetation classes. These are minimum rates of turnover because compensatory changes at the same slough cannot be measured. Turnover for immature aspen was 221 ha compared to 240 ha present in 1945–1949. For mature aspen it was 224 ha compared to 277 ha, for willows 124 ha compared to 124 ha, and for shrubs it was 86 ha compared to 93 ha present in 1945–1949. Thus, the minimum total turnover of the four vegetation types around these 396 sloughs was 655 ha compared to 734 ha present in 1945–1949.

Discussion

Alberta's aspen parkland needs to be treated regionally in considering environmental relationships or management interventions. Moss (1932) divided the parkland into a northern "poplar area," with coniferous associates, and a southern "parkland" of aspen groves and grassland parks. Others have separated a willow-aspen region along the foothills south of the Bow River, an aspen-poplar region northeast from there, and an aspen ecotone northwest from the Bow to the boreal forest (Alberta Government 1969). The parkland regions that I used for data analysis show differences both in the sloughs and in the habitats bordering them. Division of Alberta parkland into Willow-Aspen, Southern Edge, and Central regions is preliminary and the natural boundaries are undefined but these regions were meaningful in this study.

Heterogeneity of habitats bordering sloughs in all three regions, and in the total sample, had a modal index value of 1.0 (Table 3). This value indicates a norm of only one vegetation or land-use type on any side of the slough. Index values > 2.0 were as common in the Willow-Aspen and Central as they were in the total sample. Southern Edge had significantly fewer index values > 2.0 indicating that the chance of finding two different vegetation or land-use types on every side of a slough was rare in the Southern Edge.

Separation of the basic heterogeneity index into some of its major components reveals the origins of heterogeneity in the slough margins. Agricultural components contributed the total heterogeneity around 94% of sloughs in the Southern Edge compared to about 30% in all other regions. Agriculture can add important components to the heterogeneity of slough-

centered habitat mosaics, but clearly agriculture also can severely reduce the total heterogeneity of the mosaic. Because differences in land use follow ownership boundaries, the minimum area affected often is a quarter section. Woody vegetation might be expected to control heterogeneity of slough borders in the Central parkland but it does not. Few quarter sections are completely colonized by woody vegetation and these are balanced by a few with no remaining slough borders. Most quarters have slough borders narrower than 50 m and so the transects crossed them and recorded agricultural land use as a major component of total heterogeneity.

The contribution of natural habitats to total heterogeneity equals or exceeds the agricultural component in about one third of all sloughs. Natural habitats in the Central parkland are dominated by aspen and willow but frequently also included other sloughs and some natural clearing. In the Willow-Aspen parkland, natural habitats were mainly willow.

The "shrub" group was not included in the "woody" vegetation as discussed here but was an important component of natural heterogeneity. These shrubs which are important habitats for many species, including ducks, were not recorded for over 90% of sloughs even in the Central parkland. "Shrubs" were common within 50 m of sloughs only when the heterogeneity index was above 1.75.

The transect index of heterogeneity that was used here efficiently yielded meaningful quantitative data. This data base can be compared against future surveys to measure changes in the structure of habitat mosaics around sloughs. The same approach should be useful in many other situations both on the ground and from airphotos.

Both the theoretical and applied ecological literature supports the contention that heterogeneity can be related to faunal richness (Telfer 1974; MacArthur 1972; Elton 1966; Levins 1962). The losses of vegetation types recorded over the last quarter century imply that heterogeneity around sloughs is decreasing. If faunal richness is valued, these reductions in heterogeneity deserve attention in both management and research.

Changes in amount of four classes of woody vegetation during 25 to 29 years were measured around 398 of the total 913 sloughs studied. Although encroachment of woody vegetation into grassland clearings in the aspen parkland has received much attention (see, for example, Bailey and Wroe 1974; Johnston and Smoliak 1968; Moss and Campbell 1947), the net changes in woody vegetation recorded here, mainly from farming regions, are all losses. All four vegetation classes lost area from within 50 m of sloughs. Compared to the 1945–1949 areas, the 1974 areas were reduced by 32% for immature aspen, 9% for mature aspen, 68% for willow, and 74% for shrubs. Each vegetation type was reduced around the majority of sloughs, but all vegetation types were not reduced around every slough. During about three decades of this country's rapid technological change following World War II, about 408 ha of four major vegetation types disappeared from within 50 m of all the sloughs in 35 quarter sections of Alberta parkland. Average losses from each slough included nearly half a hectare of immature aspen, one third as much mature aspen, nearly a quarter hectare of willows, and almost as much upland "shrubs." Woody borders were lost completely from 32% of these sloughs while only 2% added new woody borders.

Agricultural land management is a major cause of these changes. Clearing of woody vegetation, mainly by hand, was becoming common around sloughs in the 1945–1949 airphotos. Clearing has continued with increasing technological aid from then until the end of the study. In 1974 extensive clearing was associated with intensive agriculture both on particular farms and in intensively farmed regions such as the Southern Edge of the parkland. Cultivation practices also have been important in changing these habitats. Repeated cultivation is necessary to prevent revegetation of cleared land, especially by aspen suckers. Cultivation right to the edge of sloughs and tillage of the entire slough basin are clearly important to slough habitats. It is not clear that these practices always produce substantial economic benefits for agriculture (see also, Lodge 1969). There are many examples, particularly in the Central parkland, of beef, grain, and cash-crop farming without major reductions

of slough borders.

Both natural and human forces will interact to determine the future of parkland sloughs and their bordering habitats. Merriam (1975. Aspen parkland slough habitats in Alberta. Unpublished report, Canadian Wildlife Service, Edmonton, Alberta, 68 pp.) discusses these influences in relation to management. In fact some of the present qualities of sloughs which we value may have resulted from human intervention. For example, some small deep marshes and shallow marshes which were studied in 1974 were almost totally shaded by overhanging aspen canopies in 1947. Early stages of hand-clearing were seen on 1947 airphotos. By 1974 no aspen borders remained on these sloughs but the plant and waterfowl productivity of the sloughs themselves was high, probably much higher than under those early aspen canopies. It also was evident in the field in 1974, however, that these and many other sloughs without woody borders were filling both with their own production of organic matter and with eroded soil. Clearing and cultivation of slough borders may have given many parkland sloughs a substantial boost in productivity which could drastically shorten their lifespan by accelerating filling.

Bird (1961) in a historical review of land use in Canada's parkland noted that introduction of the bulldozer into parkland agriculture in 1945–1948 was a signal event. Between 1946 and 1952 in Manitoba parkland alone Bird reported that from 120 000 to 170 000 ha were cleared and broken. More than agricultural production had to be affected by new technological interventions in the dynamics of parkland vegetation. Smith (1971) noted that "The greatest change in the Lousana environment (near Elnora, Alberta) resulted from the cutting of trees and the plowing and planting of individual pond basins . . .". Smith's data show that in 1953 on his study area, about 50% of sloughs had complete woody borders, 18% were half-bordered, and 32% were unbordered. By 1969 these figures reversed and became 28% completely bordered, 18% half-bordered, and 54% unbordered. Kiel et al. (1972) reported that for their Manitoba study area, clearing of woody slough borders increased greatly after 1954. They found that land-clearing altered more sloughs in the period 1961–1964 than in the previous 12 years (1949–1960). From 1949 to 1964 they found that 37% of 120 sloughs were altered by land-clearing. These 44 sloughs were affected 57 times by clearing operations.

My results show that heterogeneity of habitats bordering sloughs also is strongly influenced by agriculture. For example, in the Southern Edge more than 94% of slough borders derived their heterogeneity entirely from agricultural crops (Table 4). If the Willow-Aspen region were not used primarily as rangeland, it is unlikely that woody vegetation and natural features could control the heterogeneity of nearly 70% of the slough borders (Table 4). The strength of agricultural forces in the Central region is evident from differences among slough borders in Figure 1 as well as from the data. It seems clear that although habitat changes are functions of natural phenomena, they also are directed by socio-economic forces.

Goodman and Pryor (undated. A preliminary study of alteration of waterfowl habitat in the black soil zone of western Canada. Unpublished report, Canadian Wildlife Service, Edmonton, Alberta, 55 pp.) concluded that for Canada's parkland the net loss of water-surface area of sloughs by 1970 was between 14% and 23% of the pristine surface area. Net losses of entire sloughs by 1970 were between 6% and 10% of the pristine number of sloughs. My results show that changes in habitats around sloughs in Alberta's parkland were more extensive than could be inferred from the changes that Goodman and Pryor reported for the sloughs themselves. The average loss of the four major vegetation types studied was just over 1 ha per slough or 11.7 ha per quarter section during a quarter century. At the same time 33% of the sloughs studied lost their woody borders completely.

When woody slough borders are lost, most other woody parkland habitats have already disappeared. The extensive habitat changes reported here for slough borders and the reduction of heterogeneity by application of agricultural practices to whole quarter sections have changed the basic structure of Alberta parkland. The natural mosaic of grassland, woody habitats, and sloughs is becoming a coarser mosaic of more homogeneous quarter sections.

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Decline of a Ruffed Grouse Population in Manitoba

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Estimated numbers of adult Ruffed Grouse (*Bonasa umbellus*) on a 1195-ha portion of the Narcisse Wildlife Management Area near Chatfield, Manitoba, declined from 309 in June 1971 to 132 in November 1971; then to 43 in June 1972, and eventually to 18 in April 1973. Numbers of drumming males were 100, 3, and 4 in the springs of 1971, 1972, and 1973, respectively. A major decline in numbers of Snowshoe Hares (*Lepus americanus*) coincided with the decrease in grouse populations. Production of young grouse was excellent in both 1971 and 1972. Survival rates of young and adult grouse were not unusually dissimilar, but both were extremely low. Many Ruffed Grouse lost during summer 1971 were consumed by predators, and field evidence suggested that most of these were killed by the predators. We suggest that the 1971–1972 decline in numbers of Ruffed Grouse in central Manitoba may have been due to increased mortality of young and adults that resulted from a shift in diets of predators from Snowshoe Hares to Ruffed Grouse during a decline in the population of hares.

Key Words: Ruffed Grouse, populations, cycles, predation, Manitoba.

This paper documents the 1971–1972 decline in populations of Ruffed Grouse (*Bonasa umbellus*) populations in the Interlake Region of Manitoba. It describes major demographic changes accompanying the decline, and also an association between numbers of grouse, numbers of Snowshoe Hares (*Lepus americanus*), and diets of certain raptors.

Dramatic and periodic fluctuations in numbers of grouse and hares were noted by early naturalists in Manitoba (Criddle 1930; Seton 1929, pp. 705–710). Keith (1963) assembled and summarized the evidence for a 10-year cycle of several wildlife species and concluded, in part, that grouse had fluctuated cyclically in Manitoba. This conclusion was derived mainly from provincial estimates of grouse harvests, and Keith noted the paucity of estimates of grouse numbers during cyclic declines. Ransom (1965) documented a decline in numbers of Ruffed Grouse in Manitoba's Turtle Mountains during 1961–1963. He concluded that the decline was not wholly due to reproductive failure, but did not speculate on other possible causes. Gullion (1970b) recorded a decline (approximately 65%) in Ruffed Grouse populations at Cloquet, Minnesota in 1961–1964. He associated portions of the decline with unusually heavy losses to predation in 1961 (Eng and Gullion 1962; Gullion 1970a, p. 110) and again in 1963–1964 (Gullion 1970b, p. 95), but stressed the overall importance of winter weather, food supplies, and the condition-reproduction-recruitment relationship in limiting the abundance of Ruffed Grouse.

Study Area and Methods

Most of our field work from April 1971 to April 1973 was conducted on a 1195-ha portion of the Narcisse Wildlife Management Area, 1.8 km south of Chatfield, Manitoba (50°47'N, 97°34'W). Approximately 60% of the study plot was covered by upland forest. Other cover types were old fields (14%), burn (19%), and marsh (7%). The overstory of the upland forest was dominated by 20- to 30-year-old aspen (*Populus tremuloides*). The most common shrubs of the intermediate understory were Saskatoon (*Amelanchier alnifolia*), willow (*Salix* spp.), hazel (*Corylus cornuta*), and red-osier dogwood (*Cornus stolonifera*). The most common shrubs in the ground layer were rose (*Rosa* spp.) and snowberry (*Symphoricarpos occidentalis*). Densities of woody plants were estimated from 25 quarter-method (Cottam and Curtis 1956) samples with modified calculations (Rusch and Keith 1971a).

Counts of drumming males (Gullion 1966) were conducted on the Narcisse study plot in April and May 1971–1973. In spring and other seasons, numbers of Ruffed Grouse were estimated on transects by the King strip method (Leopold 1933, p. 152; Rusch and Keith 1971b). Numbers of hares tallied along these transects were used as indices to hare populations. Although all habitats on the study plot were searched and traversed, all drumming logs, Ruffed Grouse and hares were observed in or within 100 m of upland forests.

The nests of large raptors were located from aircraft in April 1971. Nests were checked for

raptor activity from the ground in May and June 1971 and 1972, and pellets and food remains were subsequently collected from active nests.

Numbers and ages of grouse in bags of hunters were obtained from check stations established at Gunton and Woodlands, Manitoba. These grouse were taken from the area between Lakes Winnipeg and Manitoba on the east and west and between the cities of Winnipeg and Grand Rapids on the south and north. In 1970 and 1971, bags were checked on the first two days of the grouse season, Fridays and Saturdays. In 1972 and 1973, bags were checked on the first two Saturdays of the grouse season.

Indices to the numbers of Ruffed Grouse harvested by hunters in 1971–1973 were obtained from unpublished data generously provided by the Manitoba Department of Renewable Resources and Transportation Services, the Minnesota Department of Natural Resources (W. H. Longley, personal communication), and the Wisconsin Department of Natural Resources (D.R. Thompson, personal communication).

Results

Because our research did not begin until April 1971, the precise time at which the decline in grouse numbers at Narcisse began is unknown. Numbers of drumming males on the Narcisse plot declined from 100 in 1971 to 3 in 1972 and 4 in 1973; estimates of numbers of adult (>12 months of age) and young (3–12 months of age) grouse in the spring declined from 309 in 1971 to 43 in 1972 and 18 in 1973 (Table 1). Indices to grouse numbers declined sharply during the summer of 1971 (Table 1); between June and September 1971, estimated numbers declined by 80% (from 1600 to 317), at a rate of 1.5 per day per 100 ha. The decline continued at a decreasing rate throughout the fall of 1971 and winter of 1971–1972 and during all of the following year. Estimates of Ruffed Grouse numbers obtained in 1974 and 1975 suggest that populations had stabilized at low levels by the spring of 1973 (D. Caswell, personal communication). In both 1971–1972 and 1972–1973, rates of decline were highest in summer and fall.

Data obtained from bag checks of hunters in the Interlake area of Manitoba provide corroboration of the severe decline in numbers of Ruffed Grouse (Table 2), as birds per hunter decreased from 1.1 in 1970 to 0.8 in 1971 and 0.1 in both 1972 and 1973. The estimates of Ruffed Grouse harvests in Manitoba (150 000, 170 000, 50 000, and 36 000 in 1970–1973, respectively) provided additional evidence of a major decline (Figure 1). The Narcisse indices, bag check data, and hunter questionnaire data imply initiation of the decline in winter 1970–1971 or spring-summer 1971.

A total of 70 drumming males was banded in the three springs (67 in 1971, 2 in 1972, and 1 in 1973). Four of these were subsequently shot and reported by hunters, all within 400 m of respective banding sites. Eight of 46 grouse less than 6 months of age when banded in the fall (43 in 1971 and 3 in 1972) were also shot and reported by hunters, all within 3.5 km of the banding sites. The mean capture-recovery distance for these eight birds was 1.2 ± 0.5 km. Nine of the 12 recoveries occurred on the study

TABLE 1—Indices (± SE) to numbers of Ruffed Grouse and Snowshoe Hares (numbers observed in parentheses) from periodic observations along transects on the 1195-ha Narcisse study plot

Date	Transect length (km)	Numbers of grouse[1]	Grouse per 100 ha[1]	Hares per 100 km
23 June 1971	182	1600±178 (156)[2]	134±15	155±14 (282)
3 Sept. 1971	182	317± 28 (44)	27± 2	23± 4 (42)
10 Nov. 1971	195	132± 7 (24)	11± 1	23± 4 (45)
22 June 1972	182	184± 65 (18)[3]	4± 3	9± 2 (16)
13 Oct. 1972	107	43± 31 (6)	3± 1	8± 3 (9)
28 Dec. 1972	161	24± 2 (8)	2± 1	5± 2 (8)
26 April 1973	182	18± 7 (4)	2± 1	2± 1 (4)

[1]Estimates calculated by King formula (Leopold 1933, p. 152) apply to all Ruffed Grouse present on the study plot. In June 1971 and 1972 juveniles were distinguished from adults and young by size. In other months, age of grouse could not be determined.

[2]Estimate includes 1291 juveniles and 309 adults.

[3]Estimate includes 141 juveniles and 43 adults.

TABLE 2—Percentage of young Ruffed Grouse in bags of hunters checked near Gunton and Woodlands, Manitoba

Dates	Numbers of hunters checked	Number of Ruffed Grouse bagged	Percentage of young grouse
September 18, 19, 1970	749	828	62
September 24, 25, 1971	1110	895	66
September 23, 30, 1972	1097	117	66
September 22, 29, 1973	397	38	76

plot. These movement data provide no evidence that egress from the study plot was excessive or that it exceeded ingress. But sample sizes are small, distribution of hunters is unknown, and the possibility of different rates of egress in different years cannot be ruled out.

Ratios of juveniles (<3 months of age) to adults among birds flushed on the study plot in June 1971 and 1972 were similar (3.3:1 and 3.5:1; chi-square = 0.006, $P = 0.96$). Percentages of young among Ruffed Grouse in bags of hunters at nearby check stations were identical (66%) in 1971 and 1972 (Table 2). This is essentially the same as the weighted and unweighted 10-year mean percentages of young in hunter bags (64% and 65%, respectively, of 3922 grouse).

Of the three drumming males present on the Narcisse plot in 1972, only one was a survivor of the 100 drumming in the previous spring; the other two were young birds. Lack of data on the sex and age structure of spring populations precludes calculation of precise survival rates for other population cohorts. Maximum survival rates, calculated from population estimates of grouse in June of 1971 and 1972 and assuming that all 43 adult grouse present in June 1972 were either one year of age or older (Table 1), were 0.03 for young (43 of 1291) and 0.14 for adults (43 of 309).

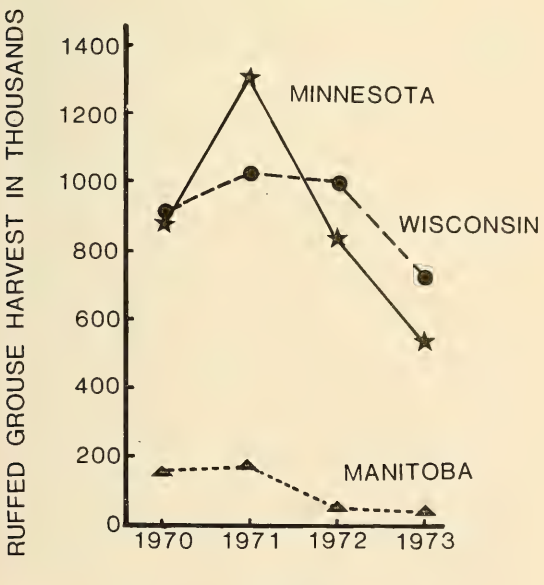

FIGURE 1. Indices to numbers of Ruffed Grouse harvested by hunters in Manitoba, Minnesota, and Wisconsin in 1971–1973.

A crew of seven men intensively searched a 40-ha area of upland forest in late June 1971. No intact carcasses of grouse were found, but remains of 14 Ruffed Grouse were located. Field evidence (Rusch and Keith 1971a) suggested that 10 of these were young that had been consumed by raptors within the previous 30 days. The 40-ha area was arbitrarily chosen because of access, but did not harbor a raptor nest or an unusually high number of drumming males (5 in 1971).

Several species of raptors hunted on the Narcisse area, and some nests of larger raptors were found. Three pairs of nesting Great Horned Owls (*Bubo virginianus*) were located on or within 400 m of the Narcisse study plot in both 1971 and 1972 and four pairs of nesting Red-tailed Hawks (*Buteo jamaicensis*) were found in each of these years. At least two pairs of Marsh Hawks (*Circus cyaneus*) utilized the area, but only one nest was found (on 29 June 1971). Raptor nests were not checked in 1973.

Grouse and hares were identified and counted in pellets and remains collected in and near these raptor nests (Errington et al. 1940; Rusch et al. 1972). A minimum of 29 Snowshoe Hares and 1 Ruffed Grouse were identified in 31 owl pellets collected in May 1971. In June and July 1971, a minimum of 61 Snowshoe Hares and 68 grouse were identified in pellets and remains at nests of Red-tailed and Marsh Hawks. In May 1972,

parts of one hare and three grouse were found in 26 owl pellets. In June and July 1972, two hares and four grouse were identified among pellets and remains at Red-tailed Hawk nests. The ratio of grouse to hares in raptor diets thus changed from 0.03:1 in spring of 1971 to 1.1:1 in summer of 1971 (chi-square = 24.2, $P \leqslant 0.005$). The latter ratio was not significantly different from the 2.3:1 ratio observed in spring and summer of 1972 (chi-square = 1.1, $P = 0.31$).

We lack data to estimate densities of Snowshoe Hares, but two independent indices suggested a severe decline in numbers of hares from 1971 to 1973. In 1971, 52 hares were captured in mirror traps during 174 trap days. In 1972 and 1973, no hares were captured in mirror traps in 19 and 11 trap days, respectively (chi-square = 12.0, $P \leqslant 0.005$). On grouse-census transects, the number of hares seen per 100 km declined from 155 in June 1971 to 9 in June 1972 and to 2 in April 1973 (Table 1).

Discussion

Harvests of Ruffed Grouse in Manitoba, estimated from questionnaire data, indicate that the decline of Ruffed Grouse populations was probably province-wide and harvest estimates from Minnesota and Wisconsin showed similar trends (Figure 1). On the other hand, estimates of harvest by resident hunters in Ontario suggested no significant change in 1970–1973 (L.R. Pim and R.M. Mitchell 1975, unpublished report, Ministry of Natural Resources, Queen's Park, Toronto, Ontario). In the past, harvests of Ruffed Grouse in Ontario, the Prairie Provinces, and the Lake States have followed generally similar trends (Keith 1963).

To our knowledge, the decline in Ruffed Grouse numbers documented at Narcisse in 1971–1973 is the most severe ever recorded. Rates of decline were highest in summer 1971 and progressively lower thereafter. Fall ratios of young to adult grouse did not change significantly during the decline, implying that reproductive failure was not an important contributing factor. Ransom (1965) reached a similar conclusion on the basis of his observations of a 1961 decline of Ruffed Grouse in the Turtle Mountains. Survival rates of both young and adult grouse at Narcisse were among the lowest ever recorded anywhere (King 1937, p. 525; Bump et al. 1947, p. 318; Palmer 1956; Dorney and Kabat 1960, p. 36; Gullion and Marshall 1968, p. 145; Rusch and Keith 1971b, p. 815).

Extrapolation from the grouse remains found on the 40-ha area searched and at three raptor nests suggests that raptors consumed at least one-half of the 18 grouse per day lost on the study plot in July-August 1971. This suggestion is tenuous because of our small sample sizes and imprecise indices to grouse numbers. On the other hand, it is unlikely that all of the grouse consumed by raptors were found in the search or tabulated at nests. In addition, Coyotes (*Canis latrans*), Red Foxes (*Vulpes vulpes*), Goshawks (*Accipiter gentilis*), and Broad-winged Hawks (*Buteo platypterus*) were also seen on the study plot and all probably consumed some grouse. Thus predators may have accounted for more than one-half of the grouse lost. We feel, as did Bump et al. (1947, p. 317), Gullion (1970b, p. 93), and Rusch and Keith (1971b, p. 818), that most of the grouse lost from the study population were probably killed by predators and consumed by them.

Data presented in this paper are not experimental, and are thus inconclusive, but support the hypothesis that cyclic declines in grouse numbers are caused by a shift in predator food habits during or after a die-off of Snowshoe Hares. This hypothesis, appealing in its simplicity, has been advanced by many other investigators such as Cabot (1912), Burnham (1918), Hewitt (1921), Cox (1936), Grange (1949, pp. 168–169), Lack (1954), Rusch and Keith (1971b), and Keith (1974, p. 45).

On the other hand, this hypothesis was challenged by Hoffmann (1958) and Keith (1963) who showed that grouse sometimes declined before hares. Although most Tetraonidae populations are thought to be limited by mortality of young after the breeding season (Bendell 1970), grouse researchers generally feel that intrinsic factors such as territorial behavior and quality of the breeding stock, or extrinsic factors such as weather and food are more important than predation in the determination of grouse numbers. We suggest that high rates of predation are sufficient to cause grouse declines but are not necessarily involved in all declines. In addition, our data do not show whether the Ruffed Grouse at Narcisse were surplus or

debilitated, thus rendering them more vulnerable to predation. Thus the data presented here are also consistent with popular hypotheses of population regulation. No one explanation of grouse declines is likely to be widely accepted without field experiments and long-term studies of the prey and predator species involved in the 10-year cycle.

Acknowledgments

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Distribution and Density of Woodchuck Burrow Systems in Relation to Land-use Practices

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Henderson, John A. and Frederick F. Gilbert. 1978. Distribution and density of Woodchuck burrow systems in relation to land-use practices. Canadian Field-Naturalist 92(2): 128–136.

Some 552 Woodchuck *(Marmota monax rufescens)* burrow systems, defined by both Woodchuck use and spatial considerations, were found on 85.7 ha of mixed farmland at Cambridge, Ontario between March and October 1973. The distribution of burrow systems for the entire study area did not differ significantly from a Poisson distribution, but densities differed with land use. The number of actively-used burrow systems per hectare averaged 5.9 and ranged from 1.8 in newly seeded pastures to 16.8 in undisturbed brushy fencerows. Uniform spacing in five fields was attributed to agnostic behavior primarily among juvenile Woodchucks during rapid invasion of new habitat. Ninety-one percent of all burrowing activity took place between April and July, and all new burrow systems were dug in recently cultivated areas. The rate of invasion of new habitat increased with the availability of vegetative cover. The number of burrow systems located in brushy fencerows remained virtually unchanged throughout the study. These fencerows served as Woodchuck "refuges" and repopulation centers for the adjacent cultivated fields.

Key Words: Woodchuck, land use, dispersal, population, farm, refugia.

The Woodchuck has been extensively studied with respect to its basic biology, primarily to elucidate physiological components of, and environmental factors affecting hibernation (e.g., Bailey 1965; Davis 1967) and changes in population status (e.g., Davis et al. 1964; Ludwig 1976; Snyder 1962). Of more immediate concern to many land-owners, particularly farmers, however, is the burrowing activity of the species and the attendant aboveground piles of excavated earth.

Moss (1940) demonstrated that Woodchuck burrow systems were clustered in relation to soil texture. Merriam (1971), however, considered heterogeneity of the physical environment and biological attraction among Woodchucks to be important in causing clustering of burrow systems. De Vos and Gillespie (1960) noted that densities of burrow systems were considerably different from one field to another and they felt the distribution was influenced by land-use practices.

The major objective of this study was to determine the distribution and density of Woodchuck burrow systems on mixed agricultural land as related to physiography, vegetational characteristics, and land-use patterns.

Materials and Methods

The study was carried out between 3 March and 22 October 1973 on 85.7 ha of mixed agricultural land on University of Guelph property located in Cambridge, Ontario (80°20′N, 43°20′W). The soils originated predominantly from sandy glacial tills. The surface layer, 20–66 cm in depth, was of a loam-to-gravelly-loam texture (Presant and Wicklund 1971). Gravel, cobbles, and stones generally underlie the surface soil layer and soil drainage is good.

Fences divided the study area into 14 units (Figure 1) representing six major types of land-use (Table 1; Figure 2). Three of the areas (1, 4, and 9) had been in pasture for more than 10 years. The vegetation in these three areas, which was predominantly orchard grass *(Dactylis glomerata)*, clover *(Trifolium hybridum)*, and dandelion *(Taraxacum officinale)* in areas 1 and 4 and orchard grass, brome grass *(Bromus inermus)*, and dandelion in area 9, was maintained at about 0.3 m or less during the summer months by periodic mowing to create a more vigorous forage crop. Three other areas (3, 5, and 8) had been hay fields and were harvested twice annually for at least 5 years prior to the study. Areas 3 and 5 were used for pasture purposes during 1973 as was area 8 in August after hay harvest. Area 3 contained primarily orchard grass, brome grass, and yellow foxtail *(Setaria glauca)*, area 5 orchard grass and brome grass, and area 8 brome grass and clover. Because of the previous land-use history of these fields and

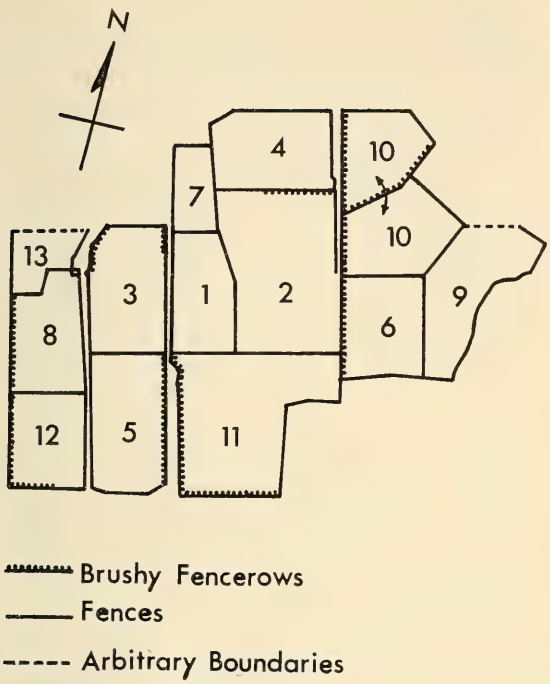

FIGURE 1. Map of study area showing land compartments and identification numbers.

FIGURE 2. Photomap of the study area showing the land compartments in 1972.

the limited impact of grazing in 1973, these fields were classified as hay fields. Area 6 had been in crops before being seeded with oats *(Avena sativa)*, alfalfa *(Medicago sativa)*, clover, and orchard grass in the spring of 1972. Cattle were allowed access to area 6 during August 1973.

TABLE 1—Locations (see Figure 1) and areas of major land-use types on the study area

Land use	Locations of land-use types	Area (ha)
Pasture	1, 4, 9	16.4
Hay	3, 5, 6, 8	23.5
Wheat	2	10.8
Seeded	10, 11, 12	24.5
Woodlot	7, 13	4.9
Fencerow	Various locations	5.6*

*There were approximately 2800 m of brushy fencerows. The actual width of the row of vegetation was everywhere less than 10 m, but the effective width of influence on burrowing sites was estimated to be closer than 20 m owing to overhead cover and root systems.

Area 2 had been in crops since 1969. It was planted with winter wheat (*Triticum* sp.) in the fall of 1972. After the wheat was harvested in early August 1973, this field was fertilized with manure and cultivated.

Areas 10, 11, and 12 were plowed in the fall of 1972, disked in May 1973, and seeded with bird's-foot trefoil *(Lotus corniculatus)* and timothy *(Phleum pratense)* in early June. All three areas had been used for grain crops for several years prior to 1973. The trefoil was mowed to a height of about 15 cm in early August and cattle were permitted to graze these fields starting the middle of September. All three fields were dominated by timothy and trefoil; dandelion, black medick *(Medicago lupulina)*, green foxtail *(Setaria viridis)*, and sand wort *(Arenaria serpyllifolia)* were also relatively abundant on area 10. Area 11 had some green foxtail and yellow foxtail and area 12 some green foxtail, sandwort, and old witchgrass *(Panicum capillare)*.

The two woodlots (areas 7 and 13) were mature stands consisting mainly of maples (*Acer* spp.), beech *(Fagus grandifolia)*, and oaks (*Quercus* spp.). The herbaceous ground cover was mainly mayapple *(Podophyllum peltatum)*, jewelweed *(Impatiens biflora)*, jack-in-the-pulpit *(Arisaema triphyllum)*, trilliums (*Trillium*

spp.), false Solomon's seal *(Smilacina racemosa)*, and a scattering of grasses (Gramineae).

The approximately 2800 m of brushy fencerows consisted of hawthorn (*Crataegus* sp.), cherry (*Prunus* sp.), oak, and several other woody species. The herbaceous plants included burdock *(Arctium minus)*, milkweed (*Asclepias* sp.), goldenrod (*Solidago* sp.), blackberry (*Rubus* sp.), raspberry (*Rubus* sp.), and several grasses (Gramineae).

The study area was gridded into 0.16-ha squares (40 × 40 m). Wooden stakes, painted orange to improve visibility, were driven at grid intersects. Each square was identified on a map by a letter and number coordinate. The descriptions of field vegetation were made from 25-cm square plots; each was positioned in a randomly selected quadrat, 2 m from the grid intersect, along a line bisecting the grid angle, i.e., 45 degrees off the grid lines. Ten percent of the grid intersects in each area were randomly selected to determine plot locations. Further vegetative data for the study area in 1973 is available from an ecological study (Lothian 1974). A topographic map was prepared from slope data obtained with an Abney level (Mosby 1971). Elevations were determined at 40-m horizontal spacing following the study area grid lines or at 20-m horizontal spacing where there was a noticeable change in slope between the grid stakes. Contour lines were interpolated at 100-m intervals.

The study area was mapped 17 April – 5 May, 10 July – 16 August, 15 October – 22 October to determine burrow locations. Actual dates of inventory were influenced by farm-management practices. Burrow systems were distinguished on the following considerations: all burrows > 10 m apart were considered to belong to separate systems; burrows < 10 m but > 3 m apart were assigned to a system only if they were connected by obvious trails, otherwise the burrows were considered to belong to separate systems; all burrows < 3 m apart were considered to belong to a common system. Individual burrows were classified as open or closed. A closed burrow was partially or entirely plugged with earth as a result of erosion, disturbance by cattle, or by Woodchuck activity. In wooded sites, a closed burrow was usually plugged with leaf litter. Burrow systems were classified as active or inactive. An active system contained one or more open burrows at which a Woodchuck was trapped or sighted or at which there was fresh sign of Woodchuck activity.

One hundred wooden boxtraps and 30 commercial wire traps provided over 64 000 trap-hours of effort. During the first trapping cycle (15 April – 7 June) each area was trapped for 10 days. The time-frame was reduced to 5 days for subsequent cycles (11 June – 6 July and 30 July – 30 August) to reduce temporal variation between areas. All open burrow systems received equal trapping effort (± 10%) within each trapping cycle. Traps were kept within 3 m of the main burrow entrance but were not placed directly at the burrow entrance. Areas 10, 11, and 12 were cultivated in May and could not be trapped. Area 13 (woodlot) was not trapped in the spring since all but eight burrow systems were still covered with leaves from the previous fall.

Traps were checked at least every 3 h to minimize loss of Woodchucks to heat stress (Simpson 1912). Captured animals were restrained in a burlap bag. Each Woodchuck was aged (Davis 1964), sexed, weighed, and permanently marked by clipping toes. The time and exact location (by grid coordinates) of each capture were recorded.

Burrow systems were tested for environmental correlates using Kendall's rank correlation modified for ties (Snedecor and Cochran 1967). Grid squares were used as the sample quadrats. Soil textural classes were ranked from 1 to 6 for the heaviest to the lightest soils respectively. Slope was derived from the contour map by measuring the change in elevation across grid squares. Scheffe's Test (Snedecor and Cochran 1967) was used to compare mean burrow densities in the two drainage classes. Vegetation was not included because the amount of diversity between areas precluded a simple ranking system.

The densities of burrow systems for the different areas were compared using Scheffe's Test (Snedecor and Cochran 1967). Areas were combined on the basis of present land use, and mean densities of burrow systems were again compared using Scheffe's Test.

Spatial distributions of burrow systems were determined on the basis of the 0.16-ha squares.

The distribution was tested using chi-square. As the detection of spatial pattern within a population could depend on the size of the sample quadrats, we calculated Morisita's I_δ-index (Greig-Smith 1964) for several quadrat sizes and graphed the values. The spatial pattern of burrow systems within fields was analyzed using Hopkin's coefficient of aggregation (Greig-Smith 1964). Since this method required an ideal sample size of 50 or more, only fields 2, 3, 5, 6, and 8 were tested. The spatial pattern in these fields and in all other areas was also tested using chi-square.

Results

Of the 472 burrow systems mapped in April, 80.3% were active. Between April and October, Woodchucks reactivated 63 old burrow systems, built 80 new systems, and abandoned 16 systems. All of the new burrow systems were dug in recently disturbed areas: 38 in the wheat field, 37 in the seeded fields, and 5 in area 6.

Most burrow systems had only one or two entrances in October owing to the large number of newly excavated systems (Table 2). In recently disturbed areas 90.5% of the systems had one or two entrances compared with 57.0% elsewhere ($P < 0.01$). Modification of entrances to burrow systems was greatest in pasture and hay fields and least in recently disturbed areas. There was no difference between the observed and a Poisson distribution of burrow systems. Burrow system densities, however, were significantly different between areas. Densities of burrow systems in areas 2, 9, 10, 11, and 12 were significantly lower ($P < 0.01$) than in areas 8, 13, and 14. The density of burrow systems in area 10 was significantly lower ($P < 0.01$) than in areas 3, 5, 6, 8, 13, and 14.

The density of burrow systems per hectare was least (1.75) in the newly seeded fields. Pasture fields (4.70) and the wheat field (4.72) had similar densities as did hay fields and woodlots with 8.43 and 8.78 burrow systems per hectare respectively. The densities in hay fields and woodlots were significantly higher ($P < 0.01$) than in pasture and wheat fields. Brushy fencerows, with 16.8 burrow systems per hectare, had the highest ($P < 0.01$) density of any land-use type (Table 3).

The shape of the graph of Morisita I_δ-index values indicated either a uniform distribution or a contagious distribution with very large clumps, the inter-clump distribution being uniform (Iwao 1970). Clumping was not detected with a quadrat size of 1.44 ha but any further increase resulted in an invalid sample size.

Based on nearest-neighbor measurements (Hopkin's coefficient of aggregation, Greig-Smith 1964), the spacing of burrow systems was significantly ($P < 0.01$) uniform in areas 2 and 8 and approached uniformity in areas 3, 5, and 6.

TABLE 2—Frequency distribution of entrances per burrow system in October. (Tested for goodness of fit to Poisson distribution)

Area	Entrances per system										Number of systems
	1	2	3	4	5	6	7	8	9	10	
1	2	6	7	3	4	2			1		25
2	31	15	3	2							51
3	21	13	2	1							55
4	7	8	5	7	2	1					30
5	6	15	10	7	3	2	1		1		45
6	8	20	10	3	3			1			53
7	4	1	3	2	3		1	1			14
8	11	20	13	5	2	8	1				53
9	6	7	6	2	1						22
10	4	3	1	1				1			10
11	14	12	1								27
12	4	2									6
13	12	7	5	3	2						29
14*	17	38	18	9	6	3	1	1		94	
Total	147	172	95	46	27	9	3	4	2	1	506

*Fencerows.

TABLE 3—Comparison of mean densities of burrow systems in each land-use type for April, July, and October (Scheffe's Test, $P < 0.05$; compare differences with 2.88). (S) — seeded fields, (Wh) — wheat fields, (Wo) — woodlots, (P) — pastures, (H) — hay fields, (F) — fencerows

Month	Burrow systems/ha								
April	0.37 (S)	<	1.11 (Wh)	<	4.29 (Wo)	4.45 (P)	<	7.37 (H)	< 16.1 (F)
July	1.51 (S)	<	4.57 (P)		4.72 (Wh)	< 8.60 (H)		8.78 (Wo)	< 16.8 (F)
October	1.75 (S)	<	4.70 (P)		4.72* (Wh)	< 8.43 (H)		8.78 (Wo)	< 16.8 (F)

*Assumed density if wheat field had not been cultivated in August.

These results confirmed those from quadrat sampling. Since certain land-use types had densities of burrow systems greater than others, the clumping indicated by the Morisita test must have occurred at the field level or higher. The clumping of burrow systems in woodlot 7 was the only contagion observed within a habitat type. The burrows were associated with a number of woodpiles in this area.

Burrow systems were significantly correlated with both slope and soil texture (Kendall's rank correlation, $P < 0.001$). But soil texture and slope were themselves correlated ($P < 0.001$).

Area 5 provided an indication that slope may influence burrow location. Soil texture, drainage, and depth and vegetation were all fairly uniform throughout the field. Over 60% of the field was nearly level, the remainder sloping moderately toward one side, yet more than half of the burrow systems were located on the slope (Kendall's rank correlation $P < 0.01$). In areas 2, 6, and 8, however, burrow systems were equally abundant on level and sloped areas.

It was not possible to test adequately the effects of soil texture on burrow sites independent of other potential causes since soils of similar texture tended to occur in large blocks, closely corresponding to field areas. Areas 5 and 6 (hay fields) were physiographically similar except for soil texture. Burrow system densities in the two areas were not significantly different. Conversely, areas 4 and 9 (pastures) differed markedly in nearly every feature except vegetation and land use, yet burrow system densities were not significantly different in these areas.

No consistent relationship was observed between burrow locations and drainage. Although the mean density of burrow systems in the imperfectly drained loams (3.70/ha) was less than in well drained loams (5.18/ha), the difference was not significant.

Our 64 728 trap-hours of effort resulted in 589 Woodchuck captures for an average of 110 trap-hours per capture. There were significant seasonal changes in the effort needed to capture a Woodchuck. The reduced effort needed to capture a Woodchuck in May and June compared with April reflected the addition of young animals to the population (Table 4). The decrease in captures in August (350 trap-hours per Woodchuck) was due to an observed lower activity of all Woodchucks. Four hundred different Woodchucks were handled (Table 5). Seventy-six percent of all females, other than juveniles, were or had been lactating when captured.

Distances between capture sites of 181 Woodchucks caught two or more times averaged 139.3 ± 94.5 m (Table 6). Although recapture distances of juveniles were consistently greater than recapture distances of adults for both sexes, only the difference between adult and juvenile females (260.2 m and 75.0 m) was significant. Time between recaptures was similar for all groups and averaged 19.8 days. Between 18 April and 20 June, 68% of recaptured adults and 78.5% of recaptured juveniles were within 100 m of their previous capture site. In contrast from 23 June to 30 August only 41% of recaptured juveniles were within 100 m of the previous capture site. During this latter time period 50% of the juveniles were relocated at more than 200 m, while only 14.5% of the adults were recaptured so far from the original capture site.

TABLE 4—Temporal distribution of Woodchuck captures

Time period (trap-hours)	Total	Number of captures			
		Adults*		Juveniles	
		Males	Females	Males	Females
18 April – 10 May (9964 trap-hours)	124	72	52	—	—
14 May – 7 June (10 170 trap-hours)	204	73	68	31	32
11 June – 6 July (20 194 trap-hours)	186	12	24	78	72
30 July – 30 August (24 400 trap-hours)	70	13	13	30	14

*Includes yearlings.

TABLE 5—Sex and age distribution of captured Woodchucks

Sex	Juvenile	Adult	Totals
Males	90	112	202
Females	94	104	198
Totals	184	216	400

Discussion

DeVos and Gillespie (1960) reported 56% of the burrow systems they investigated in May as active. This value is considerably lower than the 80% figure found in April for our study. The difference may be a function of disturbance due to fall plowing on our study area, forcing animals to use previously abandoned burrow systems for overwintering. The mean number of open entrances per burrow system in undisturbed areas (2.81) was, however, similar to the 2.98 entrances per system reported by Merriam (1971). Merriam (1971) also noted an increase in the relative occurrence of one- and two-entrance burrow systems in October as was the case in this study. He attributed this change to observational errors caused by heavy ground cover. We found that newly dug burrow systems accounted for most of the one- and two-entrance systems and usually juveniles were captured at these sites. This supports the belief of earlier investigators (Hamilton 1934; Allen and Shapton 1942; de Vos and Gillespie 1960) that dispersing juveniles dig simple burrow systems usually with a single entrance.

The density of burrow systems on the entire study area in October (5.94/ha) was greater than the 3.52/ha reported by de Vos and Gillespie (1960) for 68.2 ha of mixed farm land located about 30 km east of our study area. The main difference between the two farms was the inclusion on the latter of about 23 ha of old field that was dominated by largely inedible (Fall 1971) plants such as devils' paint brush *(Hieracium aurantiacum),* common mullein *(Verbascum thapsus),* and goldenrod *(Solidago* spp.). Similarly a decrease in Woodchuck population density in Pennsylvania was attributed to cessation of active farming operations and resultant

TABLE 6—Distances between capture sites of Woodchucks by age and sex groups for Woodchucks caught two or more times (number of recaptures in brackets)

Age	Average distance between capture sites (m)		
	Males	Females	Means
Adults*	118.1 (60)	75.0 (49)	98.7 (109)
Juveniles	170.9 (49)	260.2 (23)	199.4 (72)
Means	142.7 (109)	134.2 (72)	139.3 (181)

*Includes yearlings.

NOTE: Standard Error of Estimates = 0.6834.

plant succession (Ludwig 1976). Woodchuck populations are highest where active farming operations are occurring as the animals exploit such crops as alfalfa, clover, wheat, etc. (Hamilton 1934; Schoonmaker 1938; Grizzell 1955; de Vos and Gillespie 1960; MacClintock 1970). The pattern of burrow system density certainly reflected the animals' proclivity for field crops but was also influenced by such land-use practices as fall plowing and cultivation.

Although the distribution of burrow systems over the entire study area was random, densities were considerably below the theoretical potential based on burrow system measurements from other studies (Hamilton 1934; Allen and Shapton 1942; Grizzell 1955). Each grid square had the potential to contain 100 average burrow systems, yet the maximum observed was 10 and the average slightly less than 1. The fields which had uniformly-distributed burrow systems were those which had been cultivated and were being invaded primarily by dispersing juveniles. Other studies (Moss 1940; Grizzell 1955; Merriam 1971) have indicated a positive contagion in the spatial pattern of Woodchuck burrow systems. Only the woodlot (area 7), where Woodchucks had dug many burrows under piles of cordwood and logs, showed clustering of burrow systems. It would appear that factors other than food availability were responsible for the observed burrow system distribution.

Merriam (1971) considered biological attraction to be a necessary balance for agonistic group behavior. He found burrow systems to be in clusters on his study area and showed that movement pattern of the Woodchucks indicated systems within a cluster were more frequent than movements between clusters. He demonstrated that burrowing sites were influenced by soil drainage but he argued that the observed movement pattern of the Woodchucks indicated that biological needs other than suitable burrow sites, such as social facilitation of feeding behavior (Bailey 1965), may be satisfied by clustering of burrow systems. Social facilitation may be enhanced by clustering of burrow systems, but it was probably not a cause of the clustering. There is much evidence that social attraction does not occur during the summer (Bronson 1963, 1964; Smith 1972). The inter-burrow movement patterns observed by Merriam (1971) could possibly be explained in terms of a restriction of movements by Woodchucks to their 'home ranges' (Smith 1972).

The evidence that environmental heterogeneity may cause clustering of burrow systems is much stronger. Moss (1940) demonstrated a nearly complete restriction of burrows to certain soil textural classes. Merriam (1971) found drainage to be important in producing a clustering of burrow systems. In this study there was no area where physiographic conditions prevented Woodchucks from burrowing. Burrow systems were significantly correlated with both slope and soil texture, but soil texture and slope were themselves correlated. Furthermore, there was no difference between the observed and a random distribution of burrow systems for the whole study area but there were significant differences in the density of burrow systems between land-use types. Burrow systems were distributed randomly in 10 of the 13 areas studied. According to Odum (1971, p. 205), random distributions usually occur where the environment is very uniform and there is no tendency for the individuals in a population to aggregate. Both of these conditions were satisfied within land compartments in the present study situation. Physiography did not significantly influence the location of burrows within land-use types since areas with similar soil texture and slope tended to occur in large blocks closely corresponding to field units. Soil drainage was classed as good on 91.6% of the study area, so it was unlikely to influence the siting of burrow systems.

The difference in the densities of burrow systems between areas was apparently caused by environmental heterogeneity associated with agricultural practices. The most noticeable effect of agriculture was its influence on the vegetation. All fields were artificially planted, making plant species and densities relatively uniform within fenced areas but markedly different between areas. The qualities of vegetation also differed greatly between land-use types and were modified by mowing and harvesting and by grazing of cattle. These differences were independent of physiography. The use of organic and chemical fertilizers would reduce the differentiating effects of any natural environmental variability on the quality and quantity of vegetation. Thus

the effects of cultural practices would account for most of the differences in vegetation between land-use types, and this in turn would influence the activity of Woodchucks in an area.

The efforts of farm personnel to reduce Woodchuck numbers by gassing and shooting, although successful in increasing mortality probably caused a shift in the age structure of the population toward a preponderance of younger animals rather than a decrease in population size. Increased productivity of yearling females and a decreased net emigration of juveniles could combine to produce such an effect (Snyder 1962; Barash 1973). Data from the present study indicated that nearly 60% of yearlings lactated. This was equivalent to the maximum value found by Synder (1962) for an area where a Woodchuck population had been experimentally reduced.

Increased reproduction by yearlings enables Woodchucks rapidly to repopulate recently cultivated land. De Vos and Gillespie (1960) gave two examples of a relationship between cultivation of a field and its subsequent reinvasion by Woodchucks. One field of unspecified size was fall plowed, left in fallow for a year and planted with alfalfa, clover, and timothy the following spring. For the 5 years following plowing, the number of burrow systems was 1, 1, 8, 11, and 13. Another 4.5-ha field was plowed and seeded to alfalfa, clover, and timothy. The Woodchuck population remained at a low level for the following 6 years. These findings do not agree with those of the present study where 47 burrow systems were mapped in a 5.3-ha hay field only 1 year after being plowed and seeded to alfalfa, clover, oats, and orchard grass. Only five new burrow systems were added to this field during the second summer following plowing, indicating that the density of burrow systems was near saturation after only one season. The only apparent difference between the two study situations was that a cover crop of oats was planted in this study. Although it is not directly comparable with the above findings, 38 burrow systems were excavated in the 10.8-ha wheat field in only 4 months. Again the wheat crop would have provided cover for the Woodchucks. But perhaps more important than cover in the rapid exploitation of these fields would be the high productivity of this population and the availability of large numbers of dispersing juveniles. The great mobility of Woodchucks, particularly of juveniles, assured the invasion of unoccupied land. Juveniles moved about very little during their first month aboveground but when they did become active, they travelled much farther than adults. Bronson (1963) stated that adults made an insignificant contribution to the transient population and related it to their high relative rank. The ability rapidly to reinvade disturbed habitat would have considerable survival value, enabling Woodchucks to maintain high populations where crop rotation is practiced.

Brushy fencerows occupied only 6.4% of the study area yet contained 20.8% of all active burrow systems in July. This high density of burrow systems and the great seasonal stability in both the number of burrow systems and the number of entrances per system suggest that this habitat was of particular importance to the Woodchuck population. These areas were subjected to minimal disturbance from climatic influences and farm operations and likely served as both 'refuges' for Woodchucks displaced by cultivation of adjacent areas and as repopulation centers (as a source of juvenile animals) for the cultivated fields.

In woodlot area 13 only one Woodchuck was captured from nearly 3000 trap-hours of effort yet 22 closed burrow systems were reactivated between April and July. Grizzell (1955) believed that Woodchucks hibernated on wooded sites and moved to summer dens in crop and pasture areas. This is possible but unlikely in the present study since emergence from hibernation should have been complete (Smith 1972) before the woodlot was mapped in April and should have resulted in many burrows being opened. Eastern Cottontails *(Sylvilagus floridanus)* were fairly numerous on the farm (seven rabbits were trapped in this woodlot) and could have opened many burrows, since entrances were usually blocked only with leaves (Hamilton 1934). This was unlike the field areas where more discernible sign was usually left which allowed identification of the species opening the burrow. Also there were three active Red Fox *(Vulpes vulpes)* dens in this woodlot. Foxes are the most important natural predator of Woodchucks (Grizzell 1955; Scott and Klimstra 1955) and could have been

instrumental both in opening up burrows and in causing a decline in the Woodchuck population of the woodlot. Finally, the timing of part of the trapping effort (25–30 August) may have been partially responsible for the low number of captures as only 10 trap-days were involved for this area.

In summary, it was apparent that Woodchucks respond to man-made alterations in the environment by the juvenile segment of the population invading new habitat sites as cover and food conditions become suitable for exploitation. The ability to exploit continually and rapidly such new habitat conditions appears dependent on unaltered habitat being readily available adjacent to the disturbed sites. The pattern of land use on most mixed farming units, at least in southern Ontario, appears to provide just such conditions and undoubtedly explains the high Woodchuck densities found in areas where soil texture and drainage are suitable for the species.

Acknowledgments

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Vascular Plant Range Extensions to the Heart Lake Area, District of Mackenzie, Northwest Territories

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Cody, William J. and Stephen S. Talbot. 1978. Vascular plant range extensions to the Heart Lake area, District of Mackenzie, Northwest Territories. Canadian Field-Naturalist 92(2): 137–143.

The Heart Lake study area is briefly described. Two taxa, *Eleocharis compressa* and *Rhynchospora alba*, are reported from the continental Northwest Territories for the first time, and extensions of range for 19 additional taxa within the District of Mackenzie are recorded.

Key Words: vascular plants, District of Mackenzie, Northwest Territories, *Eleocharis compressa, Rhynchospora alba.*

In spite of increased interest and investigation of the North American boreal flora, large gaps still remain in our knowledge. Accordingly, this paper presents some of the more interesting plant records obtained from an extensive plant collection made in the Heart Lake area. The collection was made in conjunction with a phytosociological investigation (Talbot 1978) of the terrestrial and aquatic plant communities occurring in a representative portion of a small watershed within the boreal zone of southern District of Mackenzie.

The Heart Lake area (Figure 1) is located 18 km southwest of Great Slave Lake and is bounded by the geographical coordinates of 60°48′ and 60°53′N and of 116°37′ and 116°43′W. The study area surrounds Heart Lake, is irregular in shape, and is approximately 30 km² in size.

Primary contributions to our knowledge of

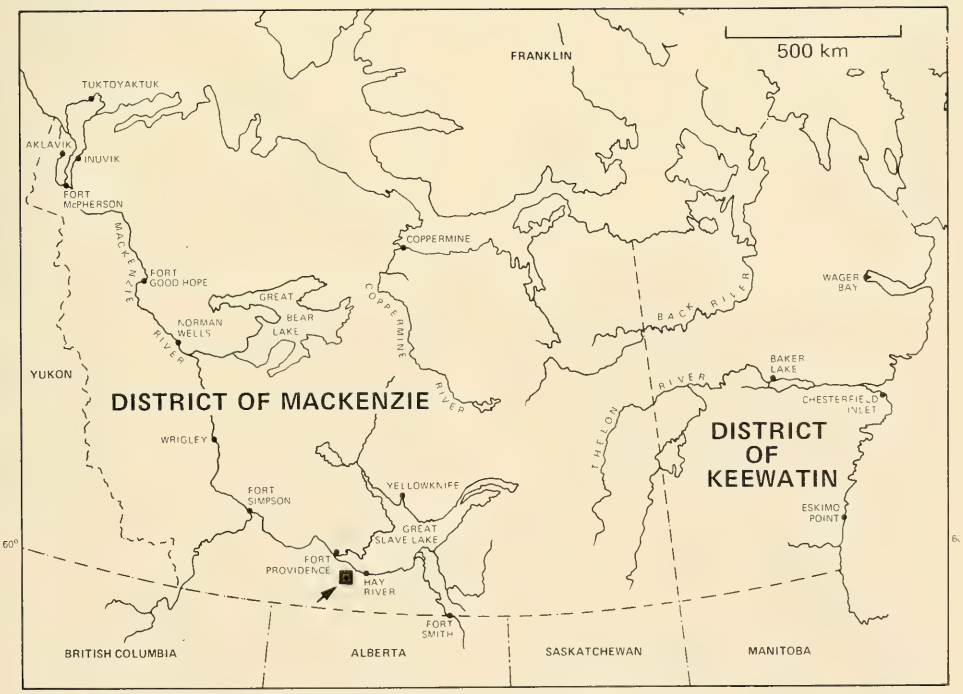

FIGURE 1. Location of Heart Lake study area in southern District of Mackenzie.

the area include the botanical investigations of the Wood Buffalo, Athabasca – Great Slave, and southwestern Mackenzie regions (Raup 1935, 1936, 1946, 1947); the bogs and forests of northwestern Alberta (Moss 1953a, b), and the flora and vegetation adjacent to the Yellowknife section of the Mackenzie Highway (Thieret 1963, 1964).

Study Area

Heart Lake lies in the southern portion of Great Slave Plain in the Interior Plains region (Bostock 1970a, b). Great Slave Plain is predominantly low-lying, almost flat ground usually below 300 m in elevation. It is characterized by low scarps of resistant carbonate strata, small shallow lakes, and organic terrain.

The entire western basin of Great Slave Lake is underlain by calcareous Upper Devonian bedrock (Douglas 1974).

Immediately after the retreat of ice, glacial Lake McConnell was formed, inundating a vast expanse, including Heart Lake. It extended from Great Bear Lake in the north through Great Slave Lake to Lake Athabasca in the south. Ancient postglacial beach ridges formed by the lake are prevalent within the Heart Lake area.

The climate of the area is cold, continental (Harris and Calder 1975). Hay River, the nearest climatic station 40 km to the east, has a mean annual temperature of –3.7°C and averages 340 mm precipitation annually. Over half the precipitation falls in the vegetative season. Summers are warm with a mean July temperature of 20.6°C.

The climatic subzone to which Heart Lake belongs may be calculated (Hämet-Ahti et al. 1974) using Holdridge's (1967) bioclimatic index, the mean annual "biotemperature." If compared on the criterion of biotemperature, the following stations which encompass Heart Lake are "middle boreal": Hay River (biotemperature, 5.1°C), Fort Simpson (5.1°C), Fort Smith (4.9°C), and Fort Providence (4.8°C).

With respect to Rowe's "Forest Regions of Canada," Heart Lake lies in the Hay River Section, B18b which "represents the northern extension of the mixedwood forest, somewhat modified by a more rigorous climate (colder and drier)" (Rowe,1972, p. 37).

The predominant upland vegetation consists of coniferous and mixed woodlands with *Pinus banksiana, Picea glauca, Populus tremuloides, Alnus crispa, Salix bebbiana, Rosa acicularis, Shepherdia canadensis, Juniperus communis, Arctostaphylos uva-ursi,* and *Elymus innovatus.*

Lowland vegetation consists of three major components: (1) wooded fens dominated by *Picea mariana, Larix laricina, Betula glandulosa, Potentilla fruticosa, Myrica gale, Salix candida, S. myrtillifolia, Arctostaphylos rubra, Equisetum pratense,* and *Mitella nuda;* (2) raised ombrotropic plateau bogs dominated by *Picea mariana, Ledum decumbens, L. groenlandicum, Chamaedaphne calyculata, Andromeda polifolia, Oxycoccus microcarpus,* and *Sphagnum fuscum*; and (3) reticulate string fens or aapamires whose surface is composed primarily of eutrophic wet hollows dominated by *Carex aquatilis, C. limosa, Scirpus caespitosus, Menyanthes trifoliata, Drepanocladus revolvens,* and *Scorpidium scorpioides.*

Flora

The vascular flora of Porsild and Cody's (1968) sixth phytogeographic province, which includes Heart Lake, numbers about 573 taxa with the total flora for the continental Northwest Territories numbering about 1135 taxa. Accordingly the relatively small Heart Lake area with 317 taxa (Talbot 1978) possesses 55.5% and 28.0% of these floras, respectively.

To a large degree the comparatively rich Heart Lake flora may be accounted for by landscape diversity, which provides a number of habitats. Examples include mesic escarpment canyons, talus, beach ridges, plateau-like uplands, raised bogs, string fens, lakes, streams, and both wooded and non-wooded fens.

The following species have been identified and documented by a representative set of voucher specimens deposited in the herbarium of the Biosystematics Research Institute, Ottawa (DAO). Species taxonomy follows Porsild and Cody (1968).

Ophioglossaceae

Botrychium virginianum ssp. *europaeum.* Roadcut in white spruce fen with *Petasites* and *Carex,* about 0.8 mi NE of Mile 81 Mackenzie Highway, *Talbot 3748.* This is a circumpolar subspecies which is found across boreal Canada, but in the District of Mackenzie previously known only from the foothills and slopes of the southern Mackenzie Mountains (Raup 1947; Cody 1963; Scotter and Cody 1974).

Polypodiaceae

Cystopteris montana. In limestone canyon below escarpment, Mile 81.6 Mackenzie Highway, 60°55′N, 116°37′W, *Talbot s.n.,* 23 July 1971. Thieret (1961) gathered a specimen on the slope above Kakisa River, 2.4 km below Lady Evelyn Falls. This and the collection cited above are the only known localities for the species near Great Slave Lake, and are the easternmost yet found in the District of Mackenzie. It is a rare species in the district, being otherwise known only from Nahanni Mountain and between Nahanni Butte and Fort Simpson (Raup 1947), and indeed is rare elsewhere in Canada because of its special springy or damp calcareous habitat requirements.

Potamogetonaceae

Potamogeton natans. Shallow pond in eutrophic wet-level fen, about 1.3 mi S of Mile 92 Mackenzie Highway, *Talbot 3700.* This is the second record of this pondweed for Mackenzie District. It is intermediate between the previously known site of Rabbitkettle Lake in the southern Mackenzie Mountains and the nearest sites to the south and southeast in southwestern Alberta and Lake Superior (Cody and Porsild 1968; Scotter and Cody 1974). Two other interesting records have been found at this same site, one reported here, *Rhynchospora alba,* and one reported previously, *Sarracenia purpurea* (Cody and Talbot 1973).

Cyperaceae

Carex filifolia. Lithic regosol on subarctic heath 0.5 mi N of Mile 80, Mackenzie Highway 60°50′N, 116°37′W, *Talbot 218.* Populations in the District of Mackenzie, Yukon Territory, and southeastern Alaska appear to be disjunct from those of the southern Prairie Provinces (Figure 2). The species is rare in the District of Mackenzie, previous collections having come from Nahanni Butte (Scotter and Cody 1974) and Wrigley (Porsild 1951).

Carex interior. Wet sedge fen, about ¾ mi N of Heart Lake Biological Station, *Talbot 2313.* Thieret (1961) reported this species as new on the basis of a collection at Mile 61 Mackenzie Highway, about 32 km distant from the site reported here. Elsewhere in the district it has since been found by hotspring ponds in the lower South Nahanni River area (Scotter and Cody 1974). It is a boreal species in North America.

Carex livida var. *grayana.* Calcareous muck, about ¾ mi N of Heart Lake Biological Station, *Talbot 2307,* shrub fen along lake margin, south end of Heart Lake, *Talbot 6052. Carex livida s. lat.* is a circumpolar species comprised of several disjunct populations. The var. *grayana* is found in North America from Newfoundland to Alaska and is boreal in its range. In the District of Mackenzie it was previously known only from the Eskimo Lake Basin (Porsild 1943).

Carex richardsonii. Subarctic heath on lithic regosol, with *Juniperus horizontalis, Arctostaphylos uva-ursi, Cladonia pyxidata, Ditrichum flexicaule,* about 0.5 mi S of Heart Lake Biological Station, 60°50′N, 116°37′W, *Talbot 247*; Pine Point, 60°50′N, 114°20′W, *Ducruc 165.17* (QFA, Photo DAO). The original description of this species gave the locality of "W," meaning "the wooded country between 54° and 64° N." This, however, did not mean that it occurred as far north as 64°, but only that it was found between those

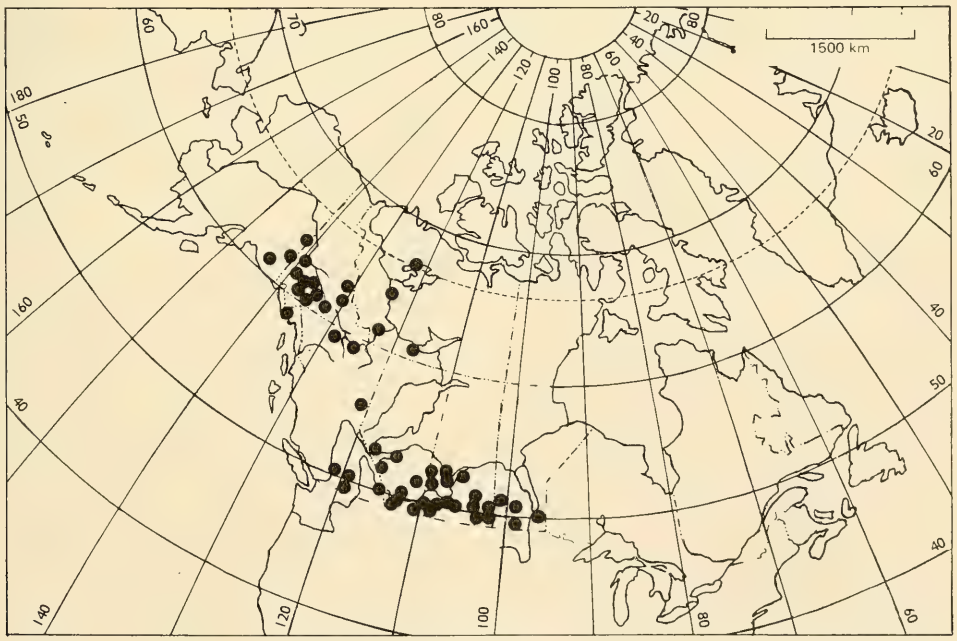

FIGURE 2. Canadian distribution of *Carex filifolia.*

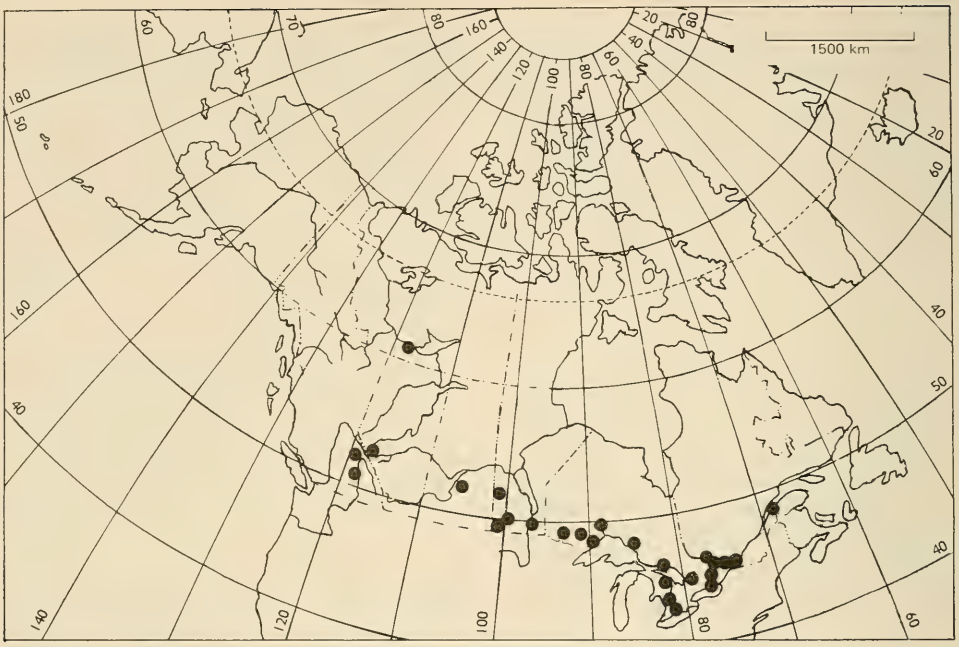

FIGURE 3. Canadian distribution of *Eleocharis compressa*.

limits. Raup (1936, 1947) collected the first District of Mackenzie specimen with accurate locality and data at Fort Smith, whence Cody (*3801, 4036*) later collected it. The specimens cited here extend the known range to near the upper Mackenzie River and thus confirm the prophecy of Raup (1947) that it would be found there. *Carex richardsonii* is a North American species which is found from the Great Lakes region west to interior British Columbia, northward slightly beyond latitude 60° N.

Eleocharis compressa. Calcareous mud N of Heart Lake Biological Station, 60°51′N, 116°37′W, *Talbot 2310, 3742*. New to the District of Mackenzie. This represents a considerable extension of the known range from Jasper in southwestern Alberta (Figure 3). *Eleocharis compressa* is readily distinguished from other species of *Eleocharis* known in the district by its three-cleft rather than two-cleft style.

Kobresia simpliciuscula. Wet fen with *Scirpus caespitosus, Triglochin maritima, Drosera anglica,* about ¾ mi N of Heart Lake Biological Station, *Talbot 2304*; in rich *Scirpus caespitosus* fen below escarpment, about 0.3 mi NW of Heart Lake Fire Tower, *Talbot 7303;* rich sedge fen, about 0.4 mi NE of Heart Lake Biological Station, *Talbot 9063*. This is a circumpolar species which in Canada is found from Newfoundland to Alaska north to Ellesmere Island. It is apparently rare in the lowland area west of Great Slave Lake.

Rhynchospora alba. Eutrophic wet-level fen with *Sarracenia purpurea,* about 1.3 mi S of Mile 92 Mackenzie Highway, 60°54′N, 116°55′W, *Talbot 3701*. This species, as can be seen from the map (Figure 4), has been found in many bogs in eastern Canada. It is known from several stations in Saskatchewan, and again in Alaska and the coastal parts of British Columbia. It is apparently absent in the extreme western part of Ontario, Manitoba, Alberta, and the interior parts of British Columbia, but should be looked for there in suitable habitats. The collection cited above is an extension of range of some 423 km to the northwest from Little Gull Lake south of Lake Athabasca in Saskatchewan (Argus 1968). It is new to the flora of the continental Northwest Territories. The somewhat similar *R. capillacea* is known from marl bogs in all three prairie provinces, but is apparently rare there. It can be distinguished from *R. alba* by its spikelets which are deep brown to castaneous rather than white or whitish-brown, three rather than mostly two stamens, and 6 rather than 10 to 12 bristles.

Orchidaceae

Cypripedium calceolus var. *parviflorum*. Black spruce fen, about 1 mi NE of Mile 84, Mackenzie Highway, *Talbot 4603*. The map in Hultén (1968) indicates several North American populations. In the District of Mackenzie this species was previously known from adjacent to the Liard and Mackenzie Rivers north to Great Bear Lake, and in the Mackenzie Mountains. It is apparently absent in northern Alberta and northern Saskatchewan and is certainly rare in the Great Slave Lake region from which the specimen cited here was obtained.

Cypripedium guttatum. *Picea glauca* – feathermoss community along riverbank, Kakisa River, 60°58′N, 117°17′W, *Talbot & Dyke 4601*. This specimen is from the most southeasterly locality yet known in the District of Mackenzie. The species is Amphi-Beringian and extends across Alaska, Yukon, and the Mackenzie Mountains to Great Bear Lake and the Mackenzie River and two sites on

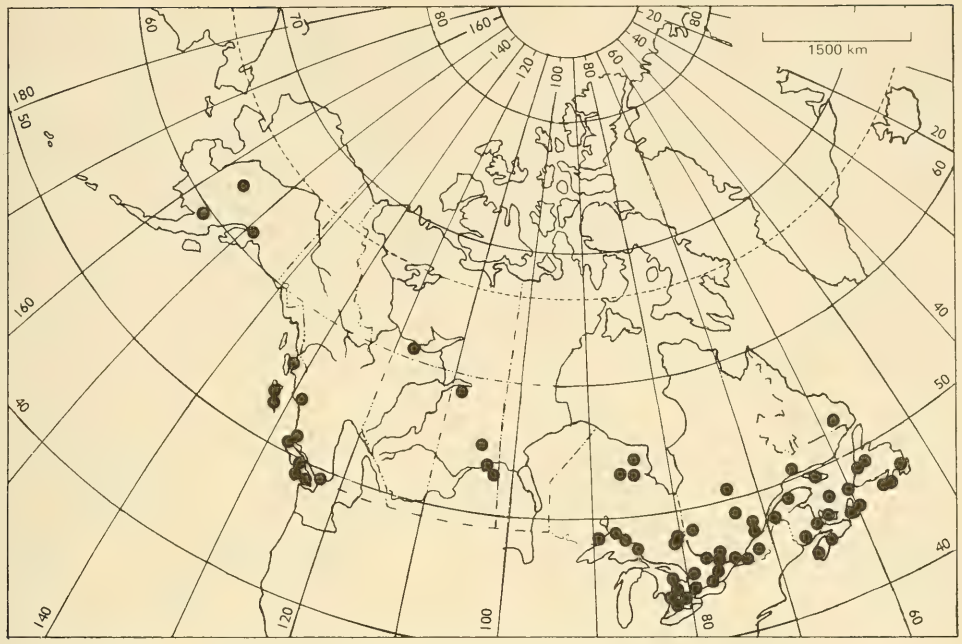

FIGURE 4. Canadian distribution of *Rhynchospora alba*.

the north and east arms of Great Slave Lake and the Kakisa River site reported here.

Caryophyllaceae

Arenaria humifusa. *Picea mariana – Tomenthypnum nitens* fen, about 1¼ mi N of Heart Lake Biological Station, *Talbot 4066*. This is a rare plant in southwestern District of Mackenzie. The present collection helps complete our knowledge of its occurrence between the east end of Great Slave Lake and the Mackenzie Mountains.

Ranunculaceae

Ranunculus abortivus. Under eves of cabin where water runoff from roof collects, Heart Lake Biological Station, *Talbot 2250*. This is a boreal species which is known from the District of Mackenzie only from west of Fort Smith, from Nahanni National Park (Cody 1956; Scotter and Cody 1974), and the collection cited above.

Cruciferae

Draba oligosperma. Lithic (calcareous-sandstone) regosol along escarpment edge, about 0.5 mi N of Heart Lake Biological Station, *Talbot 2055* (det Mulligan). This is a Cordilleran species. According to Mulligan (1972), *Draba oligosperma* is one of the most common species of *Draba* in the mountains of the western United States. It is, however, only locally common in Canada, and in the District of Mackenzie was previously known only from the southern Mackenzie Mountains adjacent to the Liard River, about Great Bear Lake and adjacent to the Mackenzie River Delta. This extension of range to the lowland region at the west end of Great Slave Lake is thus of considerable interest.

Lesquerella arctica. Lithic (calcareous-sandstone) regosol along escarpment edge, about 0.5 mi N of Heart Lake Biological Station, *Talbot 2024*. This is a North American arctic and alpine species which is found also in eastern Siberia. The nearest known sites to that reported above are in the southern Mackenzie Mountains (Raup 1947; Scotter and Cody 1974).

Rosaceae

Potentilla arguta. Lithic regosol in *Juniperus communis* barrens, about 0.5 mi NE of Mile 78 Mackenzie Highway, *Talbot 4663;* rare in partial shade of *Populus tremuloides* and *Salix* west of Le Grand Detour, Slave River, 60°21′N, 112°44′W, *Cody 13977*; occasional in dry sedge-grass prairie near Hook Lake, 3 mi E of Slave River, *Cody 14117*. Thieret (1961) reported this species as new to the District of Mackenzie on the basis of specimens collected along the Yellowknife Highway, NW of Fort Providence. Scotter (1966) reported a second collection from Blachford Lake, N of the east arm of Great Slave Lake. The specimens cited above from the prairies of the Slave River and from near Heart Lake help complete our knowledge of the distribution of this rare plant in the district. In Wood Buffalo Park, Alberta, Raup (1936) reported this cinquefoil as "common in dry prairies and rock crevices."

Ericaceae

Oxycoccus quadripetalus. Raised bog, southeast corner of Heart Lake, *Talbot 2360*. This is a boreal species which apparently is quite rare in the District of Mackenzie. Previous collections were from Norman Wells (Cody 1960, *sub Vaccinium oxycoccus*) and along the Liard River (Jeffrey 1961).

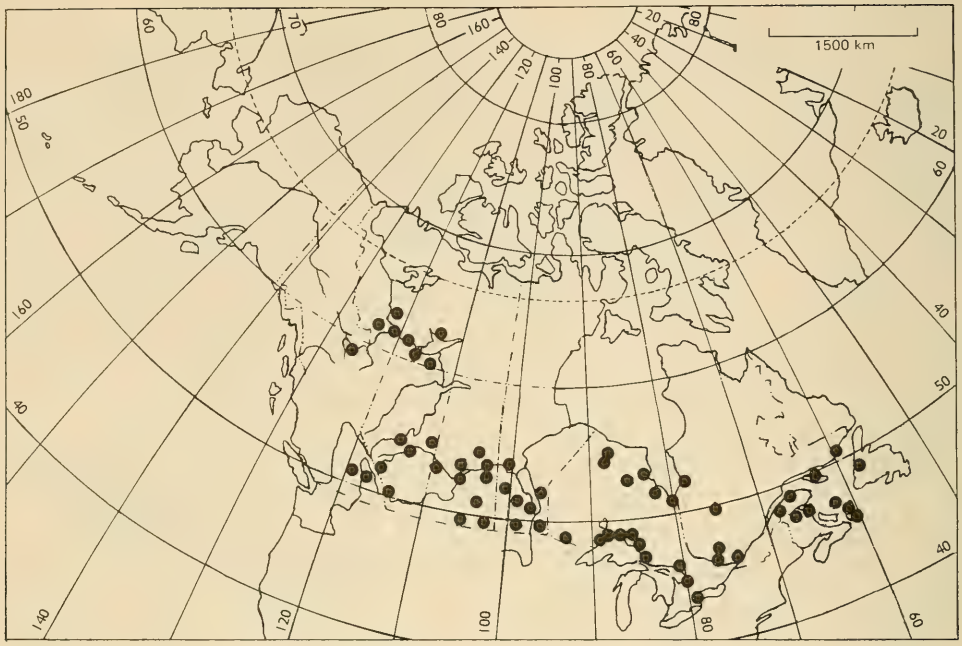

FIGURE 5. Canadian distribution of *Lobelia kalmii*.

Gentianaceae

Gentiana affinis. Rich organic hummock above wet marl, about 4 mi N of Mile 180 Mackenzie Highway, *Talbot 4681*. The presence of this species in the District of Mackenzie was first reported by Cody and Porsild (1968) on the basis of collections from the Keele River in the Mackenzie Mountains and near Fort Good Hope. Additional localities have since been found in the Keele River valley (Cody 1978), but the collection reported here helps fill in the gap between latitude 54° in southern Alberta and the Keele River sites. The species was rare at the present site.

Scrophulariaceae

Pedicularis parviflora. Shrub fen near inlet stream, southern Heart Lake, *Talbot 3702*; common in wet fen hollows between *Sphagnum* hummocks near Tetcho Lake, 60°25′N, 120°45′W, SE of Trout Lake, *Rowe 1795* (DAO). This is a plant of spotty distribution in the central part of its range; it is apparently frequent in the lowlands adjacent to Hudson and James Bay in the east, and again on the Pacific coast. There is an early report (Macoun 1884) of *P. palustris* var. *wlassoviana* "On the Mackenzie River (McGill Coll. Herb.)," but we have been unable to locate and verify this collection. The collections cited above are thus the first verified record of *P. parviflora* occurring in the District of Mackenzie. They represent an extension of range NW from the only other Mackenzie Basin collection on the north shore of Lake Athabasca in Saskatchewan (Raup 1936). In Alberta, the nearest collection site is apparently Pigeon Lake, whence G. H. Turner made several collections (DAO). In the continental Northwest Territories it is also known from the Coastal Plain of Hudson Bay at the mouth of the McConnell River in the District of Keewatin (Cody and Porsild 1968).

Lobeliaceae

Lobelia kalmii. Rich shrub fen, about 1 mi N of Mile 81.7 Mackenzie Highway, *Talbot 4673*. This is a rare plant in the District of Mackenzie, which is now known from several collections in the lowlands W of Great Slave Lake and about hot springs in the southern Mackenzie Mountains (Raup 1936, 1947; Thieret 1963; Scotter and Cody 1974). Although Hooker (1829–1840) reported this species as "in saline marshes in lat. 60°," *L. kalmii* is apparently not otherwise known from north of lat. 54°30″ (Cold Lake) in eastern Alberta except for a site in northern British Columbia at the Liard Hotsprings (Figure 5).

Acknowledgments

The research was supported by National Research Council of Canada Grant A2570 to G. H. La Roi, and a Boreal Institute Grant-in-aid 1971–1973 (S.T.). Appreciation is expressed to W. A. Fuller, Department of Zoology, University of Alberta for use of the facilities at the Heart Lake Zoological Station.

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Range Extensions and Comments on the Vascular Flora of the Continental Northwest Territories

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Cody, William J. 1978. Range extensions and comments on the vascular flora of the continental Northwest Territories. Canadian Field-Naturalist 92(2): 144–150.

Eighteen taxa, *Poa abbreviata, Poa juncifolia, Puccinellia agrostoidea, Puccinellia andersonnii, Carex arcta, Salix discolor, Rumex orbiculatus, Cerastium regelii, Stellaria umbellata, Draba lonchocarpa, Erucastrum gallicum, Leptarrhena pyrolifolia, Coelopleurum gmelinii, Polemonium acutiflorum* f. *lacteum, Castilleja yukonis, Orthocarpus luteus, Aster yukonensis*, and *Taraxacum pumilum* are reported new to the flora of the continental Northwest Territories. Range extensions are reported for an additional 33 taxa. Notes are presented on six other taxa found in the area.

Key Words: vascular plants, District of Keewatin, District of Mackenzie, Northwest Territories.

There has been considerable botanical activity in the continental Northwest Territories (Figure 1) since the publication of the checklist of the flora by Porsild and Cody (1968) and the supporting paper by Cody and Porsild (1968). Among the plant collections that have resulted from these activities, there have been a number of specimens that represent taxa new to the region, or range extensions within the region. Some of these have already been reported in the literature (Cody 1975; Cody and Talbot 1973, 1978; Mulligan and Cody 1968; Mulligan and Porsild 1969; Nagy et al. (*in press*); Scotter and Cody 1974; and Wein et al. 1974). The present paper records 18 taxa that are new to the flora of the continental Northwest Territories, range extensions within the region for an additional 33 taxa, and notes on six other taxa found in the region. Another paper (Cody et al., unpublished data) will treat additions to the flora of Nahanni National Park in the southern Mackenzie Mountains.

In the text that follows, the abbreviations KEEW and MACK stand for District of Keewatin and District of Mackenzie respectively.

Polypodiaceae

Cryptogramma stelleri. MACK: in thick moist moss below falcon's nest, east end of Carcajou Lake, Mackenzie Mountains, 64°40′N, 127°52′W, *Cody & Brigham 20943.* This collection from the central eastern Mackenzie Mountains is the second for Mackenzie District and the species is thus new to Zone 1 of Porsild and Cody (1968). The only other collection is one by J. A. Calder from the Richardson Mountains W of the Mackenzie River Delta in Zone 2 (Cody and Porsild 1968).

Cystopteris montana. MACK: Richardson Mountains, Summit Lake, 136°28′N, 67°42′W, *Packer 1356* (DAO). Porsild and Cody (1968) recorded this species only from Zone 6. The collection cited above is the first record for Zone 2, the Richardson Mountains, and is from the northernmost locality yet recorded in Canada. Here it would appear to be an expected range extension from sites in north-central Yukon Territory. Porsild and Cody (1968) inadvertently omitted reporting this species from Zone 1, whence it had been previously reported by Porsild (1945) and Raup (1947) on the basis of a collection by V. C. Wynne-Edwards from the north peak of Nahanni Mountain.

Equisetaceae

Equisetum fluviatile. MACK: Richardson Mountains, Canoe Lake, 68°13′N, 135°54′W, lakeshore, *Cody & Johansson 12896* (DAO); same locality, *Lambert s.n.,* Aug. 1965 (DAO). This species was inadvertently omitted from Zone 2 by Porsild and Cody (1968). It is known in the same latitude from the Mackenzie River Delta.

Alismaceae

Sagittaria cuneata. MACK: Mackenzie River Delta, 28 mi S of Inuvik, *Lambert s.n.,* 5 Aug. 1966 (DAO). In the District of Mackenzie this species was hitherto known from the Slave River and about Great Slave Lake. This collection is an extension of range of some 1126 km to the northwest. Elsewhere in the north it is known in southern Yukon and central Alaska. A distribution map is given in Hultén (1968).

Gramineae

Agrostis scabra. MACK: Mackenzie River Delta, 28 mi S of Inuvik, *Lambert s.n.,* 5 Aug. 1966 (DAO). This collection represents a northwestward extension of the known range of some 435 km from Norman Wells (see Cody 1960, p. 78 for discussion).

Poa abbreviata. MACK: rare, rocky north-facing slope on flattened parts where water stands for a short time, Cape Parry, 70°10′N, 124°43′W, *Parmelee 2959* (DAO). This is a high-arctic, amphi-Atlantic species. It has not previously been reported from the arctic mainland of the District of Mackenzie.

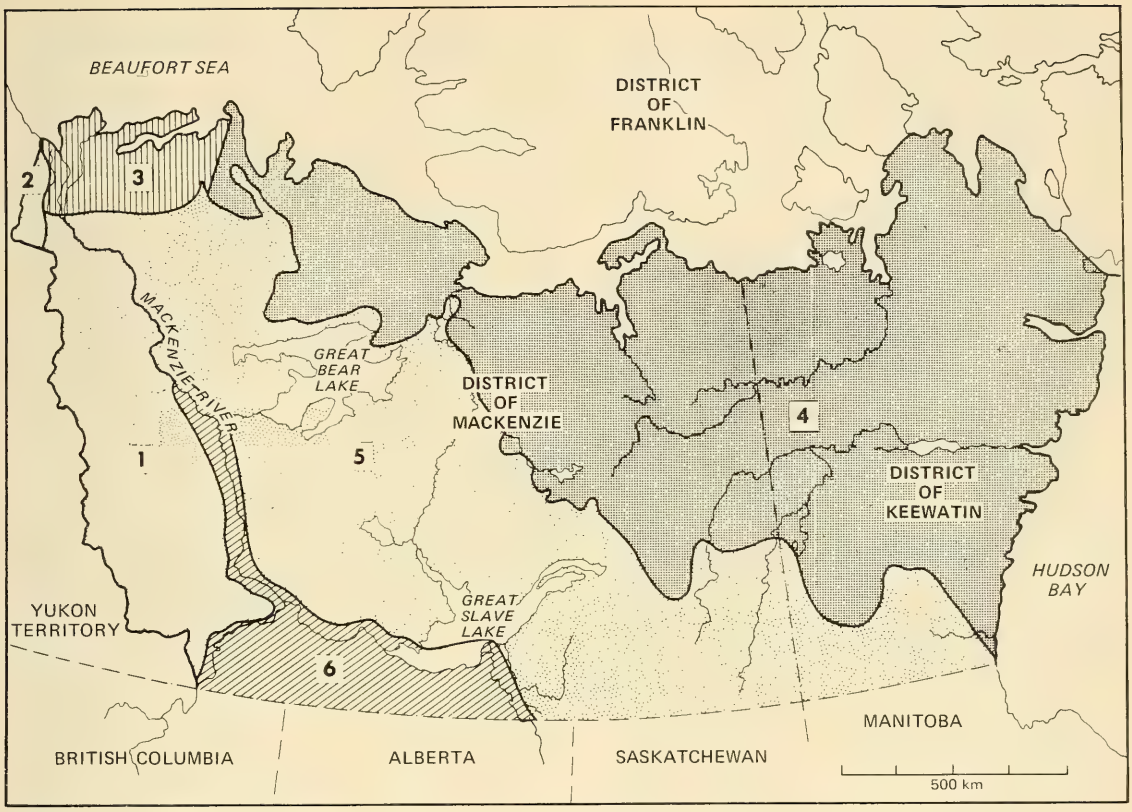

FIGURE 1. Map of the continental Northwest Territories showing floristic zones of Porsild and Cody (1968).

Poa flexuosa. KEEW: Chesterfield, *Beckett s.n.,* 25 Aug. 1955 (CAN). This is an amphi-Atlantic species which is known in our area only on the basis of the collection cited above.

Poa juncifolia. MACK: semi-wet meadow, Slave River Lowlands, northeastern Anne's Prairie near Hook Lake, 60°46′N, 112°44′W, *Reynolds 27* (DAO). This collection represents a northward extension of the known range from central Alberta. The species is new to the flora of the continental Northwest Territories and Zone 6 of Porsild and Cody (1968).

Puccinellia agrostoidea. MACK: Mackenzie River Delta, northeastern shore of Richards Island, *Cody & Ferguson 10162, 10199;* Toker Point, *Cody & Ferguson 10272*; Anderson River Delta, *Barry 464*; Nicholson Peninsula, *Parmelee 2542;* Cape Parry, *Parmelee 2974;* Clinton Point, *Parmelee 3213* (all DAO). This species was described on the basis of material from Banks Island. The range is now extended to the Arctic Coast of the District of Mackenzie. It is a non-littoral species of turfy places in tundra.

Puccinellia andersonii. MACK: Mackenzie River Delta, Richards Island, *Morrison s.n.* July 1966 (DAO); sandy soil above ocean cliffs, Tuktoyaktuk Peninsula, 70°02′N, 129°29′W, *Larsen & Owen 4242* (DAO). This is a high-arctic species known from East Greenland to Banks Island and widely disjunct to the Mackenzie Delta and Point Lay, Alaska (type locality). It is new to the flora of mainland Canada.

Vahlodea atropurpurea ssp. *atropurpurea.* MACK: in moss among stones along lakeshore and in moist depression on esker, Lynx Lake, 62°20′N, 106°25′W, *Cody 15375, 15387, 15389* (DAO); stony lakeshore, Mantic Lake, 62°18′N, 104°25′W, *Cody 15474, 15475* (DAO). KEEW: gravelly lakeshore, Baralzon Lake, 60°00′N, 98°10′W, *Scoggan and Baldwin 8363* (CAN). The collections cited here are the basis for the report of the presence of this subspecies in eastern continental Northwest Territories. *Vahlodea atropurpurea s.l.* is circumpolar; in western North America it is represented by ssp. *latifolia.*

Cyperaceae

Carex arcta. MACK: swampy area, Hjalmer Lake, 61°05′N, 109°15′W, *Scotter 3021.* This is a boreal North American species which occurs from Labrador to Alaska. It is new to the flora of the District of Mackenzie.

Carex concinna. KEEW: at base of ledge of rocks in sparse spruce timber, northwestern extremity of Nueltin Lake, *Harper 2399* (CAN). This species, which is common in western District of Mackenzie, is apparently rare in the District of Keewatin where it is known only from the collection cited above.

Carex loliacea. MACK: Mackenzie River Delta, 28 mi S of Inuvik, *Lambert s.n.,* 3 Aug. 1966 (DAO). This is a rare plant even in the southern parts of the District of Mackenzie. The collection cited here represents a northwestward extension of the known range of some 724 km from the southern part of the Mackenzie Mountains.

Carex macloviana. MACK: in pure sand of dunes, Sawmill Bay, Great Bear Lake, *Shacklette 3068* (CAN); fertile grassy slopes and herb mats, eastern slope of Mackenzie Mountains, W of Mackenzie River Delta, *Porsild 6759* (CAN); Keith Arm, Russell Bay, Great Bear Lake, 65°28′N, 122°55′W, *Porsild s.n.,* 28 Aug. 1928 (CAN); Etacho Point, Great Bear Lake, 66°0′N, 121°30′W, *Porsild s.n.,* 24 Aug. 1928 (CAN). Porsild and Cody (1968) neglected to indicate the zones in which this sedge was known to them. From Zone 1 (the western parts of the Mackenzie Mountains adjacent to the Yukon border), and Zone 6 (Mackenzie River between Blackwater River and Norman) it had been previously reported by Raup (1947). The specimens cited above indicate its presence in zones 2 and 5.

Carex sartwellii. MACK: rare along tractor trail through sedge-grass meadow W of Le Grand Detour, Slave River, 60°21′N, 112°44′W, *Cody 13947* (DAO); rare in wet sedge meadow, 3 mi N from northeastern loop of Le Grand Detour, Slave River, 60°24′N, 112°27′W, *Cody 14012* (DAO); sedge-grass meadow near Hook Lake, 3 mi E of Slave River, 60°43′N, 112°50′W, *Cody 14093* (DAO). The only other collections thus far recorded from the District of Mackenzie are those of Thieret from along the Mackenzie Highway (Thieret 1961). South of our area, the nearest known locality is Peace Point in southern Wood Buffalo Park, Alberta (Raup 1935).

Carex sychnocephala. MACK: Slave River Lowland, Sawmill Island, *Grant 1702* (DAO). This is the third collection thus far recorded for the district; other collections are from Lower Hay River and Yellowknife. *Carex sychnocephala* is a boreal North American species which occurs in Canada from southwest Quebec to the interior of British Columbia, southeastern Yukon Territory and eastern Alaska. To the south of our area this plant is known from central Wood Buffalo Park and on the shores of Lake Athabaska (Raup 1936).

Eriophorum viridi-carinatum. MACK: hot spring site, Mackenzie Mountains, Backbone Range, Twitya River, 63°56′N, 129°20′W, *Cody and Scotter 19579* (DAO). This species was previously known in the District of Mackenzie from a few collections about Great Slave Lake (Raup 1936; Thieret 1961). It is also known from the extreme southeast corner of the Yukon Territory. It is new to Zone 1 of Porsild and Cody (1968). In Canada *E. viridi-carinatum* is found from Newfoundland to British Columbia in rich bogs and peaty meadows.

Scirpus rollandii. MACK: hot spring site, Mackenzie Mountains, Backbone Range, Twitya River, 63°56′N, 129°20′W, *Cody and Scotter 19563* (DAO). Previously known in the District of Mackenzie from a single collection on the Yellowknife Highway north of Great Slave Lake (Thieret 1962). New to Zone 1 of Porsild and Cody (1968).

Scirpus rufus var. *neogaeus.* MACK: forming dense stands on shallow silty soil over stones in broad river valley, Keele River at "Caribou Flats," Mackenzie Mountains, 63°45′N, 127°54′W, *Cody 20018, Cody and Brigham 20652B* (DAO). This is not a common plant in North America. Fernald (1951) gives the following information, "Saline or brackish marshes, rarely in fresh peat, Nfld. to lower St. Lawrence R., Que., s. along coast to sw. N.S. and sw. N.B., shores of Hudson B., Man." In the herbarium of the Biosystematics Research Institute there are also several collections from Sutherland (now part of Saskatoon) in south-central Saskatchewan. This is some 724 km southwest of the collection from the Mackenzie Mountains. Hultén (1967) *sub Blysmus rufus,* repeats an earlier report by J. P. Anderson of a collection from Matanuska in Alaska, but no indication is given as to whether this should be referred to var. *rufus* or var. *neogaeus.* The Matanuska locality is 423 km W of the site reported above. *Scirpus rufus* is also known in the District of Mackenzie from near Wrigley on the Mackenzie River. The species is new to Zone 1 of Porsild and Cody (1968).

Salicaceae

Salix arctophila. MACK: Mackenzie Mountains: meadow by slough, Keele River 64°12′N, 127°25′W, *Cody and Scotter 19263* (DAO); hot spring meadow, Twitya River, 64°08′N, 128°27′W, *Cody and Scotter 19457* (DAO); wet shallow soil over stones in broad river valley, Keele River at "Caribou Flats," 63°45′N, 127°54′W, *Cody 20034* (DAO); *Sphagnum fuscum* island in sedge fen about 1 mi NE of Mile 80, Mackenzie Highway, 60°52′N, 116°36′W, *Talbot 3752* (DAO); seismic line, about 0.7 mi N of Mile 86, Mackenzie Highway, 60°52′N, 116°45′W, *Talbot 2206* (DAO); open *Picea mariana, Larix laricina* woods on marl deposit, 46 mi N of Fort Providence Junction on Yellowknife Highway, 61°47′N, 116°46′W, *Argus and Chunys 7948;* low hummock in slough, small unnamed lake on S side of Horn Plateau, 61°59′N, 119°22′W, *Cody 18584* (DAO). This is an eastern arctic species which extends westward to the Mackenzie and Richardson Mountains, and the Arctic Coast of the Yukon Territory. Porsild and Cody (1968) recorded it in their Zones 3, 4, and 5; the specimens cited above indicate its presence in Zones 1 and 6 as well.

Salix candida. MACK: Mackenzie Mountains: in shallow silty soil over stones in broad river valley, Keele River at "Caribou Flats," 63°45′N, 127°54′W, *Cody 20025* (DAO); hot spring meadow by Twitya River, 64°08′N, 128°27′W, *Cody 19996, Cody and Scotter 19492* (DAO); spring flood terrace, Keele River, 64°12′N, 127°25′W, *Cody and Scotter 19241* (DAO); hot spring site, Twitya River, 63°56′N, 129°20′W, *Cody and Scotter 19560* (DAO). *Salix candida* has been recorded from the Mackenzie Mountains, Zone 1 of Porsild and Cody (1968) only once. This was from the South Nahanni River system (Scotter and Cody 1974). The sites listed above are all from the Keele River drainage system.

Salix discolor. MACK: border of cleared ground by airstrip, Fort Simpson, *Cody and Matte 8133* (DAO); Mile 77 Mackenzie Highway, 60°48′N, 116°37′W, *Talbot 2174* (CAN); Mackenzie River, *Richardson,* Franklin Expedition (CAN) (all det Argus). The early Richardson specimen has gone unreported until this time and may have been ignored because there were no recently collected specimens to support it. *Salix discolor* is a boreal North American species which is found in Canada from Newfoundland to western

Alberta. The specimens cited above are disjunct up to 805 km from known localities in central Alberta.

Polygonaceae

Koenigia islandica. MACK: Richardson Mountains, common along west bank of Little Bell River near Summit Lake, 67°42′N, 136°28′W, *Packer 1575* (DAO). This is a circumpolar species with numerous disjunct populations. It has been collected only a few times in our area but has perhaps been overlooked. New to Zone 2 of Porsild and Cody (1968).

Rumex orbiculatus. MACK: Buffalo Lake, 60°08′N, 115°53′W, *Ducruc 194.1* (QFA, Photo DAO). This is a range extension northward from central Alberta. It is new to the flora of the District of Mackenzie and Zone 6 of the Porsild and Cody (1968).

Caryophyllaceae

Cerastium regelii. MACK: mossy moist soil near lakeshore, Tuktoyaktuk Peninsula, 70°02′N, 129°29′W, *Owen and Larsen 74-4227* (DAO). This is a circumpolar species which is common in some parts of the Canadian Arctic Archipelago. From the Canadian mainland it is known only from Melville Peninsula and the present collection. New to Zone 3 of Porsild and Cody (1968).

Gypsophila paniculata. MACK: persisting and spreading after cultivation, Fort Smith, *Cody 19117* (DAO). This native of Eurasia is widely cultivated as a herbaceous ornamental. It has escaped in various parts of Canada, and large infestations can be found in the southern parts of Saskatchewan, Alberta, and British Columbia (Darwent 1975).

Minuartia macrocarpa. This species was inadvertently reported by Porsild and Cody (1968) from Zone 2 rather than Zone 1, whence it is known from several collections (Raup 1947). Porsild (1943) has reported *M. macrocarpa* from King Point on the Arctic Coast of the Yukon Territory, near the District of Mackenzie border.

Stellaria umbellata. MACK: sheltered wet bank, Canoe Lake, Richardson Mountains, 68°13′N, 135°47′W, *Lambert s.n.,* 8 Aug. 1966 (DAO). This is an amphi-Beringian species which is disjunct from central Yukon to the locality cited above, the mountains of southwestern Alberta, Nevada, and Oregon. New to the flora of continental Northwest Territories.

Ranunculaceae

Ranunculus cymbalaria var. *cymbalaria.* MACK: Mackenzie Mountains: along river shore below salt lick, Keele River "Slew Lick" 64°13′N, 127°55′W, *Cody and Scotter 19176;* in shallow silty soil over stones in broad river valley, Keele River at "Caribou Flats," 63°45′N, 127°54′W, *Cody 20020;* steep moist stony waterway below hot spring meadow, by Twitya River about 2 mi W of Deca Creek, 64°08′N, 128°27′W, *Cody 19987.* It would appear that, at least in this part of its range, *R. cymbalaria* requires a more or less saline habitat. It has been known from the lowland adjacent to the Mackenzie River as far north as Norman Wells (Cody 1960) but is new to the flora of the Mackenzie Mountains (Zone 1 of Porsild and Cody 1968). All three collections cited above are from the Keele River drainage.

Cruciferae

Cardamine microphylla; C. minuta. MACK: Mackenzie Mountains: shattered limestone slope, alt. 5500 ft, "Coral Peaks," 65°06′N, 129°10′W, *Cody and Scotter 19599;* among rocks on alpine slope, alt. 5200 ft, "Coral Peaks", 65°03′N, 128°57′W, *Cody and Scotter 19636.* This is an amphi-Beringian species which is rare in northern Alaska, unknown in the Yukon Territory, but has been recorded from the southern Richardson Mountains near the Yukon border in northwestern District of Mackenzie (Cody and Porsild 1968). The specimens cited above again extend the known range of this rare Canadian plant into the Carcajou Range of the Mackenzie Mountains. This is a distance of some 433 km SE of the previously known Mackenzie District collections. The species is new to Zone 1 of Porsild and Cody (1968).

Draba lonchocarpa. MACK: Mackenzie Mountains: Sekwi Range: mountains on north side of June Lake, 63°31′N, 128°40′W, 5000–5500 ft, crevice in limestone rock face, *Cody 17239. Draba lonchocarpa* is a Cordilleran species which barely enters Yukon and Alaska. The one locality cited by Porsild (1951) in the Yukon Territory was from Rose-Lapie Pass, Mile 118 Canol Road. It is new to the District of Mackenzie and the continental Northwest Territories.

Erucastrum gallicum. MACK: Roadside, Fisherman Lake, 60°20′N, 123°47′W, 8 Sept. 1974, *Lamont 662* (Sask, fragment DAO); road-cut near Poplar River, 61°13′N, 121°19′W, 9 Sept. 1974, *Scotter 22817* (DAO). This is an introduced weed which is apparently spreading quickly across Canada. According to Frankton and Mulligan (1970) it first arrived in North America in 1903 and was first found in Canada at Emerson, Manitoba in 1922. New to the flora of the continental Northwest Territories.

Lesquerella calderi. MACK: locally common on wet and rubbly limestone flats and slopes about 5 mi N of Horne Lake, Richardson Mountains, 67°49′N, 135°59′W, alt. 2000 ft, *Calder 33936* (DAO). *Lesquerella calderi* is endemic to the Ogilvie Mountains of central Yukon Territory and the east and west slopes of the Richardson Mountains. The specimen cited here is the only collection thus far known from the District of Mackenzie (Mulligan and Porsild 1969).

Saxifragaceae

Leptarrhena pyrolifolia. MACK: Cirque Lake, 63°17.5′N, 130°08′W, alt. 5000–6000 ft, lower slopes by lake, *Cody and Brigham 20608* (DAO). New to the District of Mackenzie. Porsild (1951) recorded this Cordilleran-Pacific Coast species as new to the Yukon Territory. A distribution map which includes the Yukon sites is given by Hultén (1968). Because this species occurred so close to the Yukon-Mackenzie border at the northwest end of the Itsi Range adjacent to the Canol Road, Porsild and Cody (1968) suggested that it might be found as well in the District of Mackenzie.

Leguminosae

Astragalus americanus. MACK: in deep moss in *Picea glauca* woods, Mackenzie Mountains, Keele River, 64°12′N, 127°25′W, alt. 1400 ft, *Cody and Scotter 19283* (DAO). This is only the second record for this species from the Mackenzie Mountains. Scotter and Cody (1974) recorded it from the South Nahanni River drainage. Along the Mackenzie River,

A. americanus is known only as far north as Norman Wells at 65°17′N.

Oxytropis nigrescens ssp. *bryophylla.* MACK: east-facing slope, shallow soil on rocky hilltop, Canoe Lake, Richardson Mountains, 68°13′N, 135°54′W, *Cody 12962* (DAO); sparsely-vegetated shale slope, Richardson Mountains, 67°33′N, 136°12′W, *Calder 34077* (DAO); finely-weathered sandstone outcrops, Horne Lake, Richardson Mountains, 67°45′N, 136°01′W, *Calder 33876* (DAO); limestone mountainsides, June Lake, 63°30′N, 128°40′W, Mackenzie Mountains, *Cody 17155, 17439, 17454* (DAO); moist turf over limestone on mountain slope, "Banana" Lake, 63°49′N, 127°28′W, Backbone Range, Mackenzie Mountains, *Cody 17502* (DAO). This subspecies is found in many places in Alaska, but in the Yukon and Mackenzie and Richardson Mountains of the District of Mackenzie, it is apparently of rare occurrence.

Onagraceae

Epilobium arcticum. MACK: sparingly in wet moss in alpine tundra, eastern slope of Richardson Mountains, approximately 68°N, 136′W, *Porsild 6842* (CAN). This specimen was reported from the Richardson Mountains by Porsild (1943), but in error the species was not reported by Porsild and Cody (1968) for Zone 2. The other collection (*6704*) cited by Porsild (1943) *sub E. arcticum* is *E. anagallidifolium.*

Umbelliferae

Coelopleurum gmelinii; Angelica lucida sensu Hultén 1968. MACK: shrubby alpine tundra, center peak, Pointed Mountain, 60°22′N, 123°55′W, *Lamont 308* (DAO). The map in Hultén (1968) shows this species as being essentially coastal, but with an inland population apparently following the west-flowing rivers into central Alaska, and a disjunct location at the northwest end of the Itsi Range adjacent to the Canol Road (Porsild 1951) in eastern Yukon Territory. The collection cited above represents another disjunct location and the species is new to the District of Mackenzie and Zone 1 of Porsild and Cody (1968).

Ericaceae

Kalmia polifolia. MACK: Mackenzie Mountains, Mile 216 Canol Road, near the Yukon border, 63°21′N, 129°42′W, alt. 5000 ft, *Cody 19973* (DAO). A single plant was discovered in a *Betula glandulosa – Salix* community, a habitat totally unlike the wet *Sphagnum* conditions in which *K. polifolia* grows in the eastern District of Mackenzie. This species is new to Zone 1 of Porsild and Cody (1968), although Porsild (1945) had collected it at Macmillan Pass in nearby Yukon Territory.

Vaccinium quadripetalus. MACK: base of *Sphagnum fuscum* hummocks, peat plateau 6.4 km N by NNW of Fort Simpson, 61°54′N, 121°20′W, *Walker 2023* (DAO). Previously known in the District of Mackenzie from only two localities, Norman Wells and Liard River near Fort Liard (Cody 1960; Jeffrey 1961).

Gentianaceae

Gentiana affinis. MACK: Mackenzie Mountains, in turf over stones in broad river valley among low *Betula glandulosa,* Keele River at "Caribou Flats," 63°45′N, 127°54′W, *Cody 20054* (DAO); cleared low river terrace, Keele River at Canadian Wildlife Service Camp, 64°12½′N, 127°25′W, *Cody 18953* (DAO). Cody and Porsild (1968) recorded *G. affinis* as new to the District of Mackenzie on the basis of a specimen collected somewhere along the Keele River and another older but hitherto unnoticed specimen in the Lawson Herbarium from Fort Good Hope on the Mackenzie River. This was an extension of the known range of the species of some 2575 km N from the otherwise known northern limit near the North Saskatchewan River. The present collections with more exact locality data confirm the distribution along the Keele River in the Mackenzie Mountains. Another recent collection from Mile 180 Mackenzie Highway has been reported by Cody and Talbot (1978).

Gentiana raupii. MACK: Mackenzie Mountains, hummock by hot spring, Twitya River about 2 mi W of Deca Creek, 64°08′N, 128°27′W, alt. 2300–2700 ft, *Cody and Scotter 19482* (DAO). *Gentiana raupii* until now was known only from the lowlands of the Mackenzie and Liard Rivers and about western Great Slave and Great Bear Lakes. The present collection at a hot spring site extends the known range into Zone 1 of Porsild and Cody (1968) at an altitude considerably above that of the Mackenzie River.

Polemoniaceae

Polemonium acutiflorum f. *lacteum.* MACK: Mackenzie Mountains, near junction of Keele and Natla River, approximately 63°35′N, 127°55′W, *Semeniuk, s.n.,* 15 July 1972 (DAO). This white-flowered form has been noted from several places in the Yukon Territory and Alaska (Hultén 1948: Lepage 1950), but it has not previously been recorded from the District of Mackenzie.

Castilleja yukonis. MACK: grassy slopes, Seagull Cliff, Campbell Lake, 68°08′N, 133°20′W, *Porsild 2010* (CAN): *Picea glauca* woods and muskegs, Husky River, Mackenzie River Delta, about 68°N, 135°30′W, *Bryant 6623* (CAN). This is an endemic of northwestern North America which was previously known from central and southwestern Yukon and southeastern Alaska. It is new to the continental Northwest Territories and Zone 3 of Porsild and Cody (1968).

Lagotis stelleri. MACK: Mackenzie Mountains, Mile 216 Canol Road near headwaters of Tischu River, 63°22′N, 129°42′W, *Cody and Scotter 19294, Cody 19949* (DAO). *Lagotis stelleri* has previously been collected in the District of Mackenzie only from the Richardson Mountains (Porsild 1943). The present collections extend the known range from the Yukon into Zone 1 of Porsild and Cody (1968). At this site the species was frequent in moist hummocky tundra slopes.

Orthocarpus luteus. ALTA.: bank of the Salt River, 14 mi W of Fort Smith (2 mi S of Northwest Territories – Alberta border), 59°58′N, 112°23′W, *Cody and Brigham 21075* (DAO). MACK: dry meadow at edge of white spruce forest, Slave River lowlands, Hook Lake campsite, 60°43′N, 112°47′W, *Reynolds 214, 244* (DAO). These collections represent a northward extension of the known range from Peace Point in the southern part of Wood Buffalo Park

(Raup 1936). It is new to the flora of continental Northwest Territories and Zone 6 of Porsild and Cody (1968).

Plantaginaceae

Plantago eriopoda. MACK: Mackenzie Mountains, hot springs meadow by Twitya River, 64°08′N, 128°27′W, *Cody and Scotter 19455* (DAO); steep moist stony waterway below hot spring meadow, same locality, *Cody 19986a* (DAO). Bassett (1973) presented a map of the North American distribution of this species but omitted locations from the Arctic Coast E of the Mackenzie River Delta cited by Porsild (1943). Along the Mackenzie River valley it is also known from the mouth of the Keele River (*Lindsay 325* (CAN)) and between Norman Wells and the mountain, 65°17′N, 126°50′W (*Rigby 3* (CAN)). It is new to Zone 1 of Porsild and Cody (1968).

Plantago canescens; P. septata. MACK: Mackenzie Mountains, in crevices of rock, steep north bank of river, Keele River, 64°13′N, 127°32′W, *Cody and Scotter 19204* (DAO); steep moist stony waterway below hot spring meadow by Twitya River, 64°08′N, 128°27′W, *Cody 19986b* (DAO). *Plantago canescens* is frequent along the shores of the Mackenzie River; the collections cited here extend the known range into Zone 1 of Porsild and Cody (1968).

Compositae

Artemisia borealis. MACK: Mackenzie Mountains, steep moist stony waterway below hot spring meadow by Twitya River, 64°08′N, 128°27′W, *Cody 19991* (DAO). This is a circumpolar subarctic species which has previously been recorded from Zones 3, 4, and 5 of Porsild and Cody (1968). It is new to Zone 1, the Mackenzie Mountains.

Artemisia canadensis. MACK: Mackenzie Mountains, steep eroding bank of Keele River, 64°13′N, 127°27′W, *Cody and Scotter 19372* (DAO). *Artemisia canadensis* is a lowland species which has not previously been recorded from Zone 1 of Porsild and Cody (1968).

Artemisia frigida. MACK: Mackenzie Mountains, steep slope and rocky face overlooking river, Keele River, 64°13′N, 127°55′W, *Cody and Scotter 19190* (DAO); steep eroding bank of river, Keele River, 64°13′N, 127°27′W, *Cody and Scotter 19380* (DAO). *Artemisia frigida* was recorded as new to Zone 1 of Porsild and Cody (1968) on the basis of collections from the South Nahanni River drainage. The collections cited here extend the range into the Keele River drainage in the Mackenzie Mountains.

Aster alpinus ssp. *vierhapperi.* MACK: heathy area on limestone knoll above lake, Horne Lake, Richardson Mountains, 67°45′N, 136°01′W, *Calder 33912* (DAO); steep grassy slope underlain by limestone, 3 mi N of Horne Lake, Richardson Mountains, *Calder 33941* (DAO). These collections are a part of the population in the northern Yukon reported by Wein et al. (1974). In the Yukon this taxon is not otherwise known from north of latitude 63°N, and in the District of Mackenzie from north of the central Mackenzie Mountains and Great Bear Lake (Raup 1947). It is new to Zone 2 of Porsild and Cody (1968).

Aster yukonensis. MACK: Mackenzie Mountains, steep moist stony waterway below hot spring meadow, Twitya River about 2 mi W of Deca Creek, 64°08′N, 128°27′W, alt. 2300–2700 ft, *Cody 19988* (DAO); hot spring meadow, same locality, *Cody and Scotter 19451* (DAO); in shallow silty soil over stones in broad river valley, Keele River at "Caribou Flats," 63°45′N, 127°54′W, alt. 2500 ft, *Cody 20023, Cody and Brigham 20654* (DAO); west flank of Norman Range: dry frost hummocks near stream, open, Fish Lake (Hodgeson Lake), 5 mi NE of Norman Wells, 65°17.5′N, 126°38′W, alt. 600 ft, *Shewell 133* (DAO). The map in Hultén (1968) indicates collections only from the type region near Kluane Lake in southwest Yukon and from just W of 150° near the Arctic Circle in northern Alaska. The known range of this endemic species is now extended E across the Mackenzie Mountains to the west flank of the Norman Range E of the Mackenzie River. This species apparently has an affinity for saline situations. At "Caribou Flats" it shares a most interesting situation with such plants as *Gentiana affinis,* which is disjunct 2575 km from its main range S of the North Saskatchewan River (Cody and Porsild 1968), and *Scirpus rufus,* a circumpolar species which in North America is known from a single locality in Alaska, and Saskatchewan, about James Bay, and in the east, about the lower St. Lawrence River, Newfoundland, and the Maritime Provinces. *Aster yukonensis* is somewhat similar to *A. pygmaeus,* an endemic species found in northern District of Mackenzie and on the southern parts of Banks and Victoria Islands in the Arctic Archipelago. *Aster yukonensis* may be distinguished from *A. sibiricus* by its purplish pappus, a dense coating of fine glandular hairs among the flattened longer multicellular hairs on the tegules, the upper stem and upper leaves, and the generally more thinly distributed white hairs.

Crepis elegans. MACK: Mackenzie Mountains, gravel bar of river, Keele River, 64°12′N, 127°25′W, *Cody and Scotter 19386* (DAO); steep gravelly bank of river below hot spring area, Twitya River, 64°08′N, 128°27′W, *Cody 19982* (DAO). This species has its northernmost known distribution in the District of Mackenzie along the Carcajou River W of Norman Wells (Cody 1960). The specimens cited here are from near the same latitude but are the first from this latitude in the Mackenzie Mountains. Scotter and Cody (1974) have recently recorded *C. elegans* from the south Nahanni River drainage as new to Zone 1 of Porsild and Cody (1968).

Erigeron grandiflorus Hook. ssp. *arcticus.* MACK: Mackenzie Mountains, Little Carcajou Lake, 64°33′N, 128°23′W, 4000 ft, *Stelfox s.n.,* 13 July 1972 (DAO); mesic alpine tundra, north ridge of Pointed Mountain, 60°27′N, 123°52′W, *Lamont FL 373* (SASK, fragment DAO). The status and known distribution of this subspecies are discussed by Porsild (1955, 1974). It is new to Zone 1 of Porsild and Cody (1968).

Petasites palmatus. MACK: Mackenzie Mountains, steep eroding till slope overlooking river, Keele River, 64°13′N, 127°10′W, *Cody and Scotter 19369* (DAO). New to Zone 1 of Porsild and Cody (1968). *Petasites palmatus* was already known from Zones 5 and 6.

Taraxacum pumilum. MACK: Nicholson Island, Anderson River, *Porsild 16782* (CAN); open clay spots in upland tundra 60 mi E of Tuktoyaktok, Eskimo Lake Basin, *Porsild 16773* (CAN). This is a high-arctic species here reported for the first time from the mainland.

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Seasonal Food Habits of the Barn Owl (*Tyto alba*) on the Alaksen National Wildlife Area, British Columbia

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A study of Barn Owl (*Tyto alba*) food habits on the Alaksen National Wildlife Area, British Columbia, was conducted through pellet analysis from September 1974 to December 1975. From 497 pellets, 1156 individual prey animals were recovered including six species of mammals, nine species of birds, insects, fish, and a crustacean. *Microtus townsendii* was the most important prey item in the owl's diet contributing 85.4% of the total mammalian-prey biomass. It was followed by *Rattus* sp. (12.1%) and *Sorex vagrans* (1.9%). The number of animals per pellet averaged 2.33 over the study period.

Key Words: *Tyto alba*, Barn Owl, food habits, British Columbia.

In western Canada the Barn Owl (*Tyto alba*) is resident only in extreme southwestern British Columbia (Godfrey 1966). Throughout that area the largest numbers occur in and around the Fraser Valley, west to the Fraser River mouth (Campbell et al. 1974). Few food habit studies have been carried out on the Barn Owl here (Cowan 1942; Doerksen 1969; M. Wainwright, unpublished); only Cowan (1942) presented food habit data over a period of at least one year. Our paper presents data on the seasonal food habits of the Barn Owl on the Alaksen National Wildlife Area, in the Fraser River delta, British Columbia, for the period September 1974 to December 1975.

Study Area

The Alaksen National Wildlife Area is situated on Westham and Reifel Islands, deltaic islands in the Fraser River mouth, approximately 32 km south of Vancouver, British Columbia. Both islands have been dyked and are now primarily agricultural areas. Most of the study area (270 ha) is cleared fields, either under cultivation or grassland. Hedgerows along dykes and waterways consist of mixed conifers and deciduous trees. It was estimated that from two to four Barn Owls frequented the area during the study period. Although three barns are on the Wildlife Area, interior access to them was limited and as a result they were not used extensively by the owls. A number of Wood Duck (*Aix sponsa*) nest boxes were located throughout the Wildlife Area, both the horizontal and vertical types similar to those described by Bellrose (1976), and both types were used as nest sites by Barn Owls.

Adjoining the study area to the southwest is the George C. Reifel Migratory Bird Sanctuary which, along with Alaksen supports Canada's largest wintering population of waterfowl, as well as large numbers of resident and migrant shorebirds and songbirds. In total, over 230 species of birds and 12 species of mammals have been sighted on these two islands (British Columbia Provincial Museum files).

Methods

Barn Owl pellets were collected from three main roosts: one in a fencerow of Red Cedar (*Thuja plicata*), one in a hedgerow of Pacific Crabapple (*Pyrus fusca*), and one in a small Red Alder (*Alnus rubra*) – crabapple woodlot. Each roost site was cleared of pellets in early September 1974 and collections were made at least monthly until December 1975. Pellets were gathered, placed in plastic bags, and subsequently frozen until dissection took place. Whole pellets only were used for analysis.

Two methods of pellet dissection were used. The first consisted of thawing and drying the pellets, taking their measurements, then teasing them apart to reveal the prey items. Those items were identified, numbered, recorded, and stored

in small paper envelopes. A second method involved the use of chemicals. Dry pellets were measured, then placed individually in 8-oz glass jars and covered with a 1-M solution of potassium hydroxide. After the contents of each jar had soaked for 12 h, they were poured into a fine mesh sieve and rinsed with fresh water to remove the dissolved hair. Prey items were then recorded as previously noted. The latter method proved to be the easier and more efficient. Loss of skull characteristics that might aid identification was not noted.

Mammals remains were identified using Hall and Kelson (1959), Maser and Storm (1970), Banfield (1974), Cowan and Guiguet (1975), and by comparison with specimens from the British Columbia Provincial Museum and the Cowan Vertebrate Museum at the University of British Columbia. Shrews identifiable to species all appeared to be Vagrant Shrews, *Sorex vagrans*. As well, David Hawes (personal communication) reports *Sorex vagrans* to be the only shrew species found on Westham Island. We have therefore reported all shrew remains to be that species. Identification of all bird remains was verified at the Provincial Museum.

The number of individuals was determined as described in Cowan (1942). In calculating biomass, an average weight for each animal was determined from Cowan (1942), Banfield (1974), and Burt and Grossenheider (1976). As in other studies (Cowan 1942; Glue 1974), the majority of *Rattus* sp. prey in our study were juveniles as evidenced by the lack of wear of the cheek teeth and the size of the skull. Thus an average weight of 100 g was assumed for this genus (Glue 1974).

Results

From 497 pellets, 1156 individual prey animals were recovered, including six species of mammals, nine species of birds, three insects, two fish, and one crustacean (Table 1). Townsend's Vole, *Microtus townsendii*, formed 79.9% of the total prey items recovered over the study period, followed by *Sorex vagrans* (10.6%) and *Rattus* sp. (4.8%). Passerine birds found in the pellets accounted for 2.2% of the prey composition. Other items recovered include fish gill plates, beetle elytra, duck trachea and vertebrae, and one sowbug.

Frequency of occurrence of each prey species, that is the percentage of pellets in which a prey species occurs, is shown in Table 2. Mammalian-prey biomass is shown in Table 3. Because Muskrat (*Ondatra zibethicus*) does not appear to be a normal prey item in the diet of the Barn Owl, it has been omitted from the latter table.

The mean number of prey animals per pellet

TABLE 1—Species composition of prey items in Barn Owl pellets collected on the Alaksen National Wildlife Area

Species	1974		1975						Composition	
	Sept.–Dec.		Jan.–Apr.		May–Aug.		Sept.–Dec.			
	Total	%	Total	%	Total	%	Total	%	Total	%
Sowbug					1	.4			1	.1
Insect remains					3	1.1			3	.3
Unidentified fish							2	.5	2	.2
Unidentified duck	3	1.2							3	.3
Passerines[1]	5	1.9	5	2.4	7	2.5	9	2.2	26	2.2
Sorex vagrans	17	6.5	23	11.2	42	14.9	41	10.0	123	10.6
Peromyscus maniculatus	1	.4	3	1.5			2	.5	6	.5
Microtus townsendii	220	84.3	154	75.1	219	77.9	331	80.9	924	79.9
Ondatra zibethicus					1	.4			1	.1
Rattus norvegicus	10	3.8	15	7.3			22	5.4	47	4.1
Rattus sp.	3	1.2			3	1.1	2	.5	8	.7
Zapus trinotatus	2	.7	5	2.4	5	1.7			12	1.0
Total prey animals	261	100.0	205	99.9	281	100.0	409	100.0	1156	100.0
Total pellets	121		73		97		206		497	
Prey-animals per pellet	2.16		2.81		2.90		1.99		2.33	

[1]Unidentified passerines 11, *Troglodytes troglodytes* 1, *Sturnus vulgaris* 6, *Aeglaius phoeniceus* 1, *Carpodacus purpureus* 1, *C. mexicanus* 1, *Pipilo erythophthalmus* 1, *Junco hyemalis* 2, *Melospiza melodia* 2.

TABLE 2—Frequency of occurrence of prey in Barn Owl pellets from the Alaksen National Wildlife Area

Frequency of occurrence (%)	1974		1975		Average
	Sept.–Dec.	Jan.–Apr.	May–Aug.	Sept.–Dec.	
Sowbug			1.0		.3
Insect remains			3.1		.8
Unidentified fish				1.0	.3
Unidentified duck	2.5				.6
Passerines	4.1	6.8	5.1	3.9	5.0
Sorex vagrans	11.6	27.0	27.8	16.0	20.6
Peromyscus maniculatus	.8	4.1		1.0	1.4
Microtus townsendii	91.7	95.9	93.8	86.4	92.0
Ondatra zibethicus			1.0		.3
Rattus sp.	9.9	17.6	3.1	9.7	10.1
Zapus trinotatus	1.6	6.8	4.1		3.1

ranged from 1.99 to 2.90 through the study period with a total mean of 2.33.

From a random selection of 100 pellets, sizes ranged in length from 30 mm to 84 mm and in width from 19 mm to 44 mm. The mean pellet size was 56 mm by 32 mm, which is slightly larger than measurements given by Burton (1973) and Webster (1973).

Discussion and Conclusions

Analysis of food habits of the Barn Owl in our study revealed prey species consistent with those of other studies (Cowan 1942; Doerksen 1969; M. Wainwright, unpublished) for southwestern British Columbia. Coast Moles, *Scapanus orarius*, contributed significantly to the diet of the Barn Owl in Cowan's (1942) study; however, to our knowledge this mammal does not occur on our study area. *Microtus* sp. appear to be one of the most important items in the Barn Owl's diet throughout much of North America (Foster 1927; Boyd and Shriner 1954; Giger 1965; Maser and Brodie 1966; Maser 1972; Marti 1973) and Britain (Glue 1974). In our study *M. townsendii* occurred with an average frequency of 92.0% (Table 2), indicating further the importance of this small mammal to the diet of the Barn Owl. *Microtus townsendii* was the only species we recovered of that genus, notably one of the largest species in the genus. Other authors, however, have indicated, from pellet analysis, the presence of Long-tailed Voles, *M. longicaudus*, on Westham Island (Campbell et al. 1972).

Although the percent composition and frequency of occurrence can serve to indicate the relative importance of various prey species, biomass comparisons of the prey species indicate this importance far more accurately. Golley (1961) has shown that the average energy values per unit mass of animals do not differ

TABLE 3—Estimated biomass[1] of Barn Owl mammalian-prey on the Alaksen National Wildlife Area.

Species	1974		1975						Total	
	Sept.–Dec.		Jan.–Apr.		May–Aug.		Sept.–Dec.			
	Biomass (g)	%	Biomass (g)	%	Biomass (g)	%	Biomass (g)	%	Biomass (g)	%
Sorex vagrans	102	1.0	230	2.8	270	2.7	246	1.5	848	1.9
Peromyscus maniculatus	18	.2	54	.6			36	.2	108	.2
Microtus townsendii	9240	86.4	6468	77.6	9198	93.4	13902	83.8	38808	85.4
Rattus sp.	1300	12.1	1500	18.0	300	3.1	2400	14.5	5500	12.1
Zapus trinotatus	32	.3	80	1.0	80	.8			192	.4
Total mammalian biomass	10692	100.0	8332	100.0	9848	100.0	16584	100.0	45456	100.0

[1]Average weights used in calculating mammalian-prey biomass were *Sorex vagrans* 6 g; *Peromyscus maniculatus* 18 g; *Microtus townsendii* 42 g; *Rattus* sp. 100 g; *Zapus trinotatus* 16 g.

significantly. Prey species biomass can therefore be compared. In our study (Table 3) *Rattus* sp. contributed far more significantly (12.1%) to the owl's diet than did *Sorex vagrans* (1.9%) even though *Rattus* sp. occurred in fewer numbers and in a lower frequency. *Microtus townsendii*, contributing 85.4% of the mammalian-prey biomass, formed the most significant portion of the owl's diet.

Our study with an average of 2.33 prey animals per pellet is relatively consistent with studies carried out by Maser and Brodie (1966: Polk County, 2.2) and M. Wainwright (unpublished: Delta, 2.18) while differing from those given by Doerksen (1969, 3.3), Giger (1965, 4.0), and Maser and Brodie (1966: Benton County, 1.4). The differences appear to depend on the percent composition of relatively large-biomass prey animals in the diet, particularly *Microtus* sp. Where the percentage of *Microtus* sp. is high (e.g., Maser and Brodie 1966: Benton County, 90.96%) the number of skulls per pellet is lower than that when the percent composition is low (e.g., Giger 1965, 53.4%; Doerksen 1969, 76.14%) and the diet does not include other large-biomass prey animals such as *Rattus* sp. This seems reasonable, for the owl would have to increase its intake of small-biomass animals in the latter case in order to maintain the same level of energy input.

All of the prey species of the Barn Owl in this study have been captured or observed on the study area by the authors with the exception of Pacific Jumping Mice, *Zapus trinotatus*. As well, considerable data have been gathered by University of British Columbia researchers on *Microtus townsendii* populations for parts of our study area. Boonstra (1977) reports *M. townsendii* numbers on a 0.7-ha grid ranging from a peak of 231 animals in 1972 to a low of 46 animals in the spring of 1973. He indicated the population seemed to be going through a typical cycle. Boonstra (1977) also mentions that *Sorex vagrans* was common but at very low densities (two to six per hectare).

The common prey species of the Barn Owl at Alaksen are those that frequent the owl's favored hunting habitat and, like the owl, are primarily nocturnal. Only one mammal species that frequented treed habitats (Deer Mice, *Peromyscus maniculatus*) was found in the pellets, as was the case in Cowan's (1942) study. It appeared during the cool wet months of the year, possibly when the availability of favored prey decreased. The frequency of occurrence of *M. townsendii* remained relatively stable, dropping only slightly in the two September–December periods. *Sorex vagrans* occurred in the owl's diet with greater frequency during the summer months presumably owing to the addition of young animals to the population along with their increased movements and higher vulnerability. The frequency of *Rattus* sp. on the other hand, decreased dramatically during the summer. This may have been a result of the greater availability of favored or easier-to-catch prey species during that period, as postulated with *S. vagrans*. Other authors (Cowan 1942; Glue 1974) have mentioned the apparent reluctance of the Barn Owl to capture large prey such as *Rattus* sp. The presence of a juvenile Muskrat is thus likely an incidental occurrence in the Barn Owl's diet. We could find no evidence in the literature of Muskrats being recorded as anything but an incidental prey item of the Barn Owl (Marti 1973; M. Wainwright, unpublished). Juvenile Muskrats may be near the limit in size and aggressiveness that Barn Owls will attempt to capture, although some surprisingly large and aggressive animals (e.g., cottontails, *Sylvilagus* sp., and weasels, *Mustela* sp.) have been reported in the diet of Barn Owls (Otteni et al. 1972; Banks 1965; M. Wainwright, unpublished). There is, of course, the possibility that the owl was scavenging an already dead Muskrat.

All species of birds whose remains occur in the pellets (Table 1) are common at Alaksen and all but the Starling (*Sturnus vulgaris*) commonly frequent the woodlot edges and hedgerows. Most birds that fell prey to the owls were probably taken from their evening roosts. Since Starlings and Barn Owls are both known to use Wood Duck nest boxes it is not inconceivable that Starlings were occasionally trapped and captured in such a nest box. The frequency of occurrence of passerine birds in the Barn Owl's diet remained relatively stable throughout the year with only a slight increase in the spring and summer months.

Insect remains have been reported in other studies (Cowan 1942; Earhart and Johnson

1970; Glue 1974), and Burton (1973) notes that Barn Owls have been seen "plunging into a pool like an osprey to seize a fish." Those items formed a negligible part of the Barn Owl's diet in our study, however, and must be considered incidental to the owl's diet.

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Demographic and Dietary Responses of Great Horned Owls during a Snowshoe Hare Cycle

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Population demography and food habits of Great Horned Owls (*Bubo virginianus*) on 162 km² in central Alberta during 1966–1975 were importantly affected by a cyclic fluctuation of Snowshoe Hares (*Lepus americanus*). Non-breeding was observed among territorial pairs of owls when estimated hare densities on 1 April were below 0.9/ha of habitat. Mean clutch size among owls exhibited significant yearly variation which could be only in part related to Snowshoe Hare and small-mammal densities. Snowshoe Hares were totally absent from the spring diet of horned owls by 1975 when hares were scarce, but still comprised 50% of the owls' food consumption in winter. Functional (dietary) responses to changing Snowshoe Hare densities produced changes in the biomass of food supplied to young owls that paralleled the hare cycle. The amplitude of fluctuation in horned owl numbers at Rochester was markedly increased by ingress during 1967–1971 and egress during 1972–1975. Territoriality may have prevented a further increase in the peak owl population between 1971 and 1972. The owls declined 1 year after the hares, but would have declined 2 years after if a major emigration had not occurred in 1972–1973. Mean rates of nesting by yearling horned owls have been estimated at 21 and 24%.

Key Words: predation, cycles, raptors, hares, boreal forest.

A study of Great Horned Owls (*Bubo virginianus*) was conducted in central Alberta during 1966–1975. Its objective was to examine changes in the demography and food ecology of the owl population over one complete cycle of abundance of the Snowshoe Hare (*Lepus americanus*). Early results of this work were reported by Rusch et al. (1972) and McInvaille and Keith (1974). These investigators evaluated findings through 1971, the year of peak spring densities of hares on the study area. They examined intraspecific relationships among the owls and interspecific relationships with the Red-tailed Hawk (*Buteo jamaicensis*) population. They also examined the effect of increasing hare densities on the breeding biology of the horned owls and certain interactions with prey species other than the hare.

Snowshoe Hares declined at Rochester after spring 1971, reaching the lowest point in their cycle by spring 1975. This paper describes the dynamics of the horned owl population, its dietary response to declining hare densities, and probable applications of our Rochester findings to northern horned owl populations generally.

Study Area and Methods

The 162-km² study area (130 km² in 1966) was a block of mixed agricultural and forested land near Rochester, Alberta, 97 km north of Edmonton. Luttich et al. (1971) and Rusch et al. (1972) described the vegetation, topography, and land-use practices on the area. McInvaille and Keith (1974) classified the major habitats and outlined their distribution as of 1971. Except for continued revegetation of burned areas, and minor clearing of forested land for pasture, the area remained unchanged over the next 4 years.

Methods of censusing raptors, tethering nestlings for food studies, and estimating prey population densities were identical to those described by McInvaille and Keith (1974). Estimates of Snowshoe Hare and Ruffed Grouse (*Bonasa umbellus*) numbers have been revised slightly, however, as additional analyses were completed. We expanded small-mammal monitoring to include a spring (April-May) index during 1973–1975. Waterfowl population indices were based on aerial counts along a 0.4-km-wide transect between the towns of Cold Lake and Swan Hills, passing 11 km north of Rochester.

Results and Conclusions

Prey Populations

Spring (1 April) densities of Snowshoe Hares near Rochester peaked in 1971 at 510/100 ha of

TABLE 1—Estimated densities and population indices of prey on the raptor study area near Rochester, Alberta

Species density or index	Months	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Snowshoe Hares/ 100 ha[1]	1 Apr.	24	39	93	144	340	510	245	78	23	5
Ruffed Grouse/100 ha[2]	Apr.–May	32	35	61	42	46	32	16	15	15	34
Sharp-tailed Grouse											
dancing ground[3]	Apr.–May	10	14	25	31	49	10	—[4]	22	19	20
aerial count[5]	Nov.–Mar.	54	62	54	70	112	8	39	15	8	4
Voles and mice/ 1000 trap-nights[6]	Aug.–Sept.	57	160	92	136	82	67	142	95	101	38
	Apr.–May								20	38	30
Waterfowl[7]	May						120	101	94	95	63

[1]Mean number of adults on four study areas. Density estimates for 1966–1971 have been revised since the publication of McInvaille and Keith (1974), but population trend was similar.
[2]Mean number of adults on four study areas. Density estimates for 1966–1971 have been revised since the publication of McInvaille and Keith (1974), but population trend was similar.
[3]Maximum number of males observed on one dancing ground near Rochester.
[4]Original dancing ground was abandoned; the new one was located in 1973.
[5]Mean number observed per 100 km^2 during two to five helicopter flights covering approximately 180 km^2 and overlapping about half the raptor study area.
[6]*Microtus pennsylvanicus, Peromyscus maniculatus, Clethrionomys gapperi.*
[7]Number of individuals observed in a 0.4-km aerial transect between the towns of Cold Lake and Swan Hills. The transect passed about 11 km north of Rochester. (Data courtesy of K. Duane Norman, U.S. Fish and Wildlife Service.)

habitat, then declined more than 50% by 1972. By 1975 there were 5 hares/100 ha, only 1% of peak levels (Table 1).

Ruffed Grouse densities were highest in spring 1968 at 61/100 ha of habitat. A 65% decline to 16/100 ha occurred between the springs of 1970 and 1972. Densities remained low through spring 1974, then more than doubled by 1975. There was a marked decrease among Sharp-tailed Grouse (*Pedioecetes phasianellus*) between 1970 and 1971. Numbers thereafter remained relatively low through 1975. Waterfowl indices for 1971–1975 indicated an overall decline of about 50%.

During 1971–1975, small-mammal populations continued to fluctuate markedly. There had been fall population peaks in 1967 and 1969, and another occurred in 1972; there were lows in 1971 and 1975. Spring populations were higher in 1974 than in 1973 and 1975 (Table 1).

Great Horned Owl Numbers and Reproduction

Great Horned Owls increased on the study area from 5 pairs (1 breeding) in 1966 to at least 16 pairs (all breeding) by 1971. There were also 16 breeding pairs in 1972; but the population decreased thereafter to 5 pairs by 1975. Nesting attempts ceased during this decline, with only 1 of 13 pairs laying eggs in 1973 and none of 8 and 5 pairs in 1974 and 1975 (Table 2). Although we could not be certain of the total number of resident pairs present during 1970–1972, we believe that no non-breeding territorial pairs were missed; and thus, as in 1968 and 1969, total breeding pairs equalled total resident territorial pairs.

The mean date of hatching for horned owl clutches was slightly later in 1972 (21 April) than in 1970 and 1971 (14 and 18 April, respectively), though still earlier than in 1967–1969 (range 28 April – 4 May). Mean clutch size varied significantly ($P < 0.05$) among years, being largest (3.1) in 1970 and smallest (1.9) in 1969. Hatching success averaged 98% (range 94–100%) for all years except 1971. In 1971, hatching success dropped to 84%. Of the five pairs not hatching complete clutches that year, three were late nesters. McInvaille and Keith (1974) believed that these were yearlings, breeding a year ahead of the normal because of peak hare densities.

The nature of spacing within the 1972 horned owl population was tested for randomness using Clark and Evans' (1954) "nearest neighbor test" (see McInvaille and Keith 1974). As in earlier

TABLE 2—Some population statistics for the Great Horned Owl on a 162-km² area (130 km² in 1966) near Rochester, Alberta

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Resident territorial pairs	5	6	8	9	?[1]	?	?	13	8	5
Breeding (laying)	1	3	8	9	7	16	16	1	0	0
Non-breeding (non-laying)	4	3	0	0	?	?	?	12	8	5
Eggs hatched/successful nest[2]	2.0	2.3	2.1	1.9	3.1	2.0	2.6	—[3]	—	—
Percent mortality of young from hatching to fledging[4]	0	11	25	19	14	9	29	—	—	—

[1]Increased number of owls and apparent movements from winter hooting positions to spring nesting sites prevented accurate estimates of total resident pairs.

[2]These figures include some nests not on the 162-km² area: i.e., one in 1966, five in 1967, three in 1968, one in 1969, two in 1970, six in 1971, and four in 1972.

[3]The single active nest in 1973 failed prior to hatching.

[4]Young dying from handling and starvation were treated as unnatural mortality and excluded from this sample because such losses did not appear among untethered birds off the study area.

years, the distribution of owl pairs on the study area was significantly ($P < 0.05$) regular, thus indicating the continued influence of territoriality as a spacing mechanism within the breeding population.

Relationship between Breeding Activity and Snowshoe Hare Density

Our data suggest that there may be a critical overwinter hare density below which breeding by the territorial owl population becomes depressed. When early spring hare densities were below 0.9/ha of habitat, some resident pairs of horned owls failed to nest. In 2 of 5 such years, there were no known nesting attempts (Figure 1.)

During a period of hare scarcity in the 1960s in Saskatchewan, Houston (1971) observed numerous territorial pairs of horned owls for which he could find no nests. During the next hare decline, owl numbers on a 32-km² area dropped from at least nine pairs (all breeding) in 1971 to three (none breeding) in 1973 (Houston 1975). These data, in conjunction with ours at Rochester, indicate that changes in numbers and breeding rates of horned owls in response to varying hare densities are regional phenomena.

Relationships between Clutch Size and Prey Density

Large clutches in Tawny Owls (*Strix aluco*) have been associated with high prey populations (Southern 1959); and Houston (1971) reported the largest clutches of horned owls in Saskatchewan in years of peak hare and/or mouse densities. Increases in clutch size in high prey years have been observed in several other species of owls as well (Lack 1966, pp. 146–147).

A similar relationship existed with horned owls at Rochester. For example, in spring 1970, when *Microtus pennsylvanicus* were conspicuously abundant and hares were near their peak, mean clutch size was the largest recorded (3.1). In 1967, small mammals were abundant and hares were scarce, whereas in 1971 the situation was reversed: in these two years average clutch size was intermediate (2.4). In 1968 and 1969, small mammals were apparently not abundant, as evidenced by spring food habits (discussed later), and hare densities were intermediate: in these two years average clutch size was smallest (2.0).

The situation in 1972 was, however, anomalous: small mammals were little utilized and hence probably scarce, and hares were reduced to intermediate levels; yet mean clutch size (2.7) was the second largest recorded.

Ingress and Egress

We calculated *net* ingress or egress annually (Table 3) from observed changes in numbers of territorial pairs and fledged young at Rochester, together with post-fledging mortality rates obtained through life-table analyses of regional banding data (Adamcik and Keith 1978). The term 'net' is emphasized because young horned owls apparently disperse from natal territories after fledging. Such movements are usually short-range (within 80 km) and directionally unpredictable (Stewart 1969; Adamcik and Keith 1978), but would likely carry young fledged on our study area beyond its boundaries,

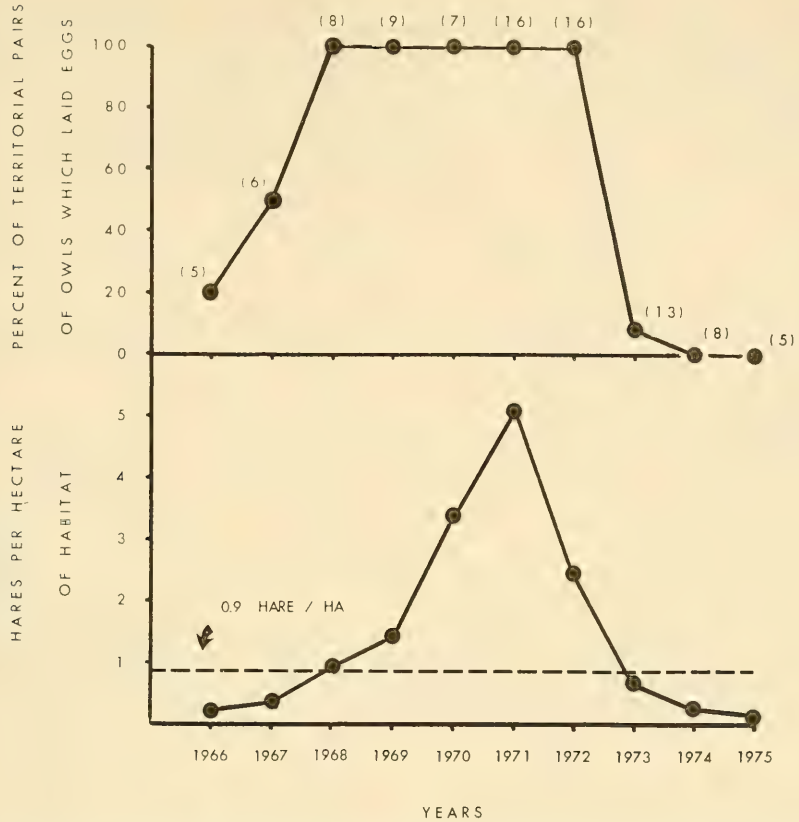

FIGURE 1. Relationship between Great Horned Owl nesting and estimated densities of Snowshoe Hares on a 162-km² study area (130 km² in 1966), 1 April, near Rochester, Alberta. Figures in parentheses are known numbers of territorial pairs of owls on the area.

while young fledged elsewhere may or may not move into the area. If the number leaving equalled the number arriving, *net* ingress and egress would both be zero.

Mean annual mortality rates of Great Horned Owls banded as nestlings in forest and parkland regions of Alberta, Saskatchewan, and Manitoba were 55% in the first year of life, 39% in the second, and 22% thereafter (Adamcik and Keith 1978). There was no detectable difference in post-fledging mortality as owl populations increased and decreased in relation to the hare's cyclic fluctuations; hence, we applied the same mean rates of mortality each year when calculating ingress and egress at Rochester (Table 3).

Ingress contributed importantly to the increase of horned owls at Rochester during 1966–1971 (Table 3). If, as is generally believed, territoriality and nesting are not evident among yearlings (birds approaching 1 year of age), then ingress accounted for between 31 and 58% of the territorial owls present during 3 years of population growth. If all yearlings had entered the territorial cohort, ingress would still have exceeded 30% in 3 of 5 years from 1967 to 1971. Conversely, egress played a major role in the ensuing population decline, being equivalent to 62% of the remaining territory holders in 1974 (if these were adults only), and 35% in 1973 (if both yearlings and adults were territorial). Overall, increases in numbers were always associated with ingress and decreases were associated with egress.

Food Habits

Snowshoe Hare biomass in the spring diet of horned owls exhibited an approximately four-

TABLE 3—Calculated ingress and egress of Great Horned Owls on a 162-km² study area near Rochester, Alberta. Post-fledging survival rates based on analysis of horned owl banding data from forest and parkland regions of Alberta, Saskatchewan, and Manitoba

		Numbers of Great Horned Owls in different age classes									
		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Observed:	Territorial owls (A)	10	12	16	18	14	32	32	26	16	10
Expected survivors from previous year:	Adults[1] (B)		6.8	8.2	10.9	12.2	9.5	21.8	21.8	17.7	10.9
Observed:	Fledglings	2	6	13	14	19	29	30	0	0	0
Expected survivors from previous year:	Yearlings[2] (C)		0.9	2.7	5.9	6.3	8.6	13.1	13.5	0	0
	Adults[3] (D)			0.5	1.6	3.6	3.8	5.2	8.0	8.2	0
Net ingress:											
If both adults and yearlings territorial = A–(B+C)			4.3 (36%)	5.1 (32%)	1.2 (7%)		13.9 (43%)				
If adults only territorial = A–(B+D)				7.3 (46%)	5.5 (31%)		18.7 (58%)	5.0 (16%)			
Net egress:											
If both adults and yearlings territorial = A–(B+C)						4.5 (32%)		2.9 (9%)	9.3 (35%)	1.7 (11%)	0.9 (9%)
If adults only territorial = A–(B+D)						1.8 (13%)			3.8 (15%)	9.9 (62%)	0.9 (9%)

[1]Based on a mean annual survival rate 0.68; this is the average survival for horned owls after 1 year of age. This value was used since it was not known if the "territorial owls" consisted of yearlings as well as adults.
[2]Based on a mean annual survival rate during the first year after fledging of 0.45.
[3]Based on a mean annual survival rate during the second year after fledging of 0.61.

fold increase (from 23 to 81%) during the 1966–1971 upswing in the hare cycle. Concomitant with the subsequent decline in hare numbers was decreased utilization to zero by the 1975 nesting season. Birds in general, and waterfowl in particular, exhibited the opposite trend in the owls' diet, and were evidently strongly buffered when hares were abundant (Table 4). The relative importance of small mammals in the diet was lowest in 1968, 1969, 1971, and 1972, and thus not predictably related to their own abundance or that of the hare (Table 1). There were, however, notable increases in consumption of voles, weasels, and Red Squirrels (*Tamiasciurus hudsonicus*) during 1974 and 1975 as hares declined to extreme scarcity.

The winter diet of horned owls during 1971–1972 to 1974–1975 was apparently much more stable, despite the steady decline in hare densities. Total food biomass was at least 90% Snowshoe Hare through 1973–1974. In 1974–1975, hares were at their lowest level, but still the forest zone when hares had become scarce. We think it much less likely that the apparent staple food item reflects the simplicity of the prey base at Rochester in winter; there are few alternative prey species.

Dietary Biomass of Prey

The dietary biomass of prey brought to tethered young owls (Table 6) increased significantly during the last 2 years of the hare population increase. Broods received an average of 347 g daily during 1967–1969, and 905 g daily during 1970 and 1971; individual young received 175 and 370 g during the same periods. This marked rise was attributable to increased utilization of Snowshoe Hare during the last two years. The average biomass of hare supplied daily to individual young increased nearly fourfold (mean 78 g in 1967–1969 vs. 293 g in 1970–1971), whereas that of other species changed little as hare densities rose.

In 1972, the first spring of reduced hare numbers and the only one in which owls reared young, the average biomass supplied daily per brood and per individual young remained high (839 and 380 g, respectively). Hares comprised 64% of the total dietary biomass in 1972 (Table

TABLE 4—Spring (1 April – 30 June) food habits of Great Horned Owls near Rochester, Alberta[1]

	Percent frequency										Percent biomass									
Prey species[2]	66	67	68	69	70	71	72	73	74	75	66	67	68	69	70	71	72	73	74	75
Snowshoe Hare	2	4	10	8	13	27	23	9	2	0	23	34	50	50	77	81	64	70	16	0
Pocket Gopher	12	7	19	21	2	9	7	3	6	3	15	6	10	14	1	3	2	3	8	5
Mice and voles	73	69	54	55	80	48	37	75	78	79	18	11	6	8	12	4	2	12	22	27
Other mammals	4	3	3	1	1	2	4	2	4	4	12	7	6	1	1	1	2	1	7	39
Total mammals	91	83	86	85	96	86	71	89	90	86	68	58	72	73	91	89	70	86	53	71
Ruffed Grouse	4	2	2	0	tr[3]	tr	2	1	0	0	23	6	4	0	1	tr	1	1	0	0
Sharp-tailed Grouse	0	tr	3	1	tr	tr	tr	0	0	0	0	2	10	3	tr	tr	tr	0	0	0
Waterfowl	1	4	4	6	2	7	23	2	4	2	7	20	10	18	7	9	26	8	24	14
Other birds	4	10	5	8	3	5	4	9	7	12	2	14	3	6	1	2	2	6	24	16
Total birds	9	16	14	15	5	13	29	12	11	14	32	42	27	27	9	11	29	15	48	30
Totals	100	99	100	100	101	99	100	101	101	100	100	100	99	100	100	100	99	101	101	101

[1]Total numbers of food items were 114, 986, 518, 338, 756, 775, 773, 204, 125, and 131 in 1966–1975; biomass totals (in grams) were 12 103, 174 786, 140 027, 71 778, 193 736, 321 489, 370 230, 36 335, 12 951, and 10 816, respectively. Sources of food habits data were pellets collected at adult roosts; and pellets and prey items collected at nest sites and sites at which young were tethered.

[2]Prey not specifically identified in the table were as follows: "Mice and voles"—*Microtus pennsylvanicus* (averaged 74% of small mammal biomass), *Peromyscus maniculatus* (20%), *Clethrionomys gapperi* (5%), *Zapus hudsonius* (trace), and *Sorex cinereus* (trace). "Other mammals"—*Ondatra zibethicus, Tamiasciurus hudsonicus, Spermophilus richardsonii, S. franklinii, Glaucomys sabrinus, Mustela frenata, M. rixosa, M. erminea.* "Waterfowl"—*Anas platyrhynchos, A. acuta, A. strepera, A. discors, A. carolinensis, Mareca americana, Spatula clypeata, Aythya americana, A. collaris, A. affinis, Fulica americana, Bucephala albeola, Podiceps grisegena, Porzana carolina, Rallus limicola.* "Other Birds"—*Falco sparverius, Accipter cooperii, Buteo jamaicensis, Columba livia, Perdix perdix, Phasianus colchicus, Pica pica, Perisoreus canadensis, Charadrius vociferus, Turdus migratorius, Dendrocopos villosus, Sphyrapicus varius, Sturnus vulgaris, Colaptes auratus, Dendroica petechia,* and unidentified songbirds and domestic chickens.

[3]Less than 0.5%.

TABLE 5—Winter (1 December – 31 March) food habits of Great Horned Owls near Rochester, Alberta[1]

	Percent frequency				Percent biomass			
Prey species[2]	1971–72	1972–73	1973–74	1974–75	1971–72	1972–73	1973–74	1974–75
Snowshoe Hare	89	83	26	7	98	97	90	50
Mice and voles	0	9	67	78	0	tr[3]	5	13
Other mammals	11	2	4	8	2	tr	2	12
Total mammals	100	94	97	93	100	98	97	75
Ruffed Grouse	0	5	0	0	0	2	0	0
Other birds	0	0	4	8	0	0	3	26
Total birds	0	5	4	8	0	2	3	26
Totals	100	99	101	101	100	100	100	101

[1]Food habits in winter were determined entirely from pellets collected at roosts. Total pellets were 9, 36, 11, and 27 in 1971–72 through 1974–75. Total number of food items were 9, 42, 27, and 77 in 1971–72 through 1974–75; biomass totals (in grams) were 11 000, 48 737, 10 508, and 13 649, respectively.

[2]Prey not specifically identified in the table were as follows: "Mice and voles"—*Microtus pennsylvanicus* (averaged 54% of small mammal biomass), *Peromyscus maniculatus* (34%), *Clethrionomys gapperi* (9%), and *Sorex cinereus* (1%). "Other mammals"—*Tamiasciurus hudsonicus, Mustela vision, M. erminea, M. frenata,* and unidentified mammals. "Other birds"—*Columba livia, Pica pica, Perdix perdix,* and domestic chickens.

[3]Less than 0.5%.

TABLE 6—Prey biomass (in grams) brought to tethered Great Horned Owl young

	1967	1968	1969	1970	1971	1972
Average biomass per day per brood[1]						
Snowshoe Hare	126	175	161	734	693	537
Other species	245	174	160	219	163	302
Total	371	349	321	953	856	839
Average biomass per day per young						
Snowshoe Hare	56	85	95	253	333	243
Other species	110	84	95	75	78	137
Total	166	169	190	328	411	380

[1]Numbers of Great Horned Owl broods tethered were 8, 8, 7, 8, 9, and 12 from 1967 to 1972, respectively.

4), indicating that their availability was still important in enabling adult horned owls to feed their young.

Discussion

A Life Equation for Northern Horned Owl Populations

We found that when hares were scarce, reproductive recruitment to the owl population was low or zero with resident pairs failing to nest. This prompted construction of a life equation to assess the requisites for long-term maintenance of northern horned owl populations.

We assumed that mean clutch size, hatching success, and nestling survival rates at Rochester during 1966–1975 were representative of regional owl populations elsewhere in forested sections of the three Prairie Provinces. This assumption is consistent with previously published information (Henny 1972; Houston 1971; Murray 1976). We likewise assumed that estimates of post-fledging survival obtained from bandings since 1955 within this same ecosystem were applicable (Adamcik and Keith 1978).

Our life equation (Table 7) first examined the consequences of adults only breeding at the mean rate of 0.66 recorded among territorial pairs at Rochester during 1966–1975. The resulting life equation predicted a decreasing population, with 1000 eggs subsequently generating 884 eggs.

This projected decline of about 12% per generation (5.5 years) is inconsistent with the apparent long-term stability of horned owl populations in Canada and the United States (Fyfe 1976; Henny 1972). The least reliable components of our life equation are probably the post-fledging survival estimates which are based on only 155 band recoveries. The sensitivity of the life equation to minor errors in survival estimates is illustrated by the fact that an increase in first-year survival from only 0.45 to 0.51 would produce population stability.

An alternative explanation for the predicted population decline is that our assumption of non-breeding by yearlings is incorrect. The widely accepted idea that Great Horned Owls do not breed as yearlings seems to be wholly untested in the field, even though Hickey (1952) pointed out the need for such information 26 years ago. In the most relevant paper, Weller (1965) concluded from bursa regression that: ". . . most individuals do not breed until two years old, although some yearling females may breed." By 1 year of age the bursa was one-half to one-third its initial depth, and by 2 years was largely regressed. Weller also stated, however, that two females, in evident breeding condition, had bursas designating them as yearlings. That large owls have at least the potential to nest as yearlings was shown by Flieg and Meppiel's (1972) captive Snowy Owls (*Nyctea scandiaca*).

Henny (1972) calculated a yearling nesting rate from the proportion of yearlings in the population (34%) as given by a life table, an overall non-nesting rate (26%) reported by four studies in the United States, and the assumption that all non-nesters were yearlings. Because of a minor computing error, Henny's estimate of 23% yearling nesting should be revised slightly to 21%. This figure is very close to the 24% yearling nesting calculated by us (Table 7) as another way of balancing a life equation for northern Great Horned Owls.

TABLE 7—Life equation for a Great Horned Owl population based on observed clutch size, hatching success, and nestling survival at Rochester, and subsequent survival rates calculated from banding data from forest and parkland regions of Alberta, Saskatchewan, and Manitoba

Approximate age interval	Age class	Number alive at start of interval	Interval survival rate[1]	Proportion breeding[2]	Eggs laid in interval[3]
0–5 weeks	eggs	1000	0.96		
5–10 weeks	nestlings	960	0.92		
0.2–1.2 years	nestlings and juveniles	883	0.45		
1–2 years	yearlings	397	0.61	(0.24)[4]	(116)
2–3 years	adults	242	0.78	0.66	194
3–4 years	adults	189	0.78	0.66	152
4–5 years	adults	147	0.78	0.66	118
5–6 years	adults	115	0.78	0.66	92
6–7 years	adults	90	0.78	0.66	72
7–8 years	adults	70	0.78	0.66	56
8–9 years	adults	55	0.78	0.66	44
9–10 years	adults	43	0.78	0.66	34
10–11 years	adults	33	0.78	0.66	26
11–12 years	adults	26	0.78	0.66	21
12–13 years	adults	20	0.78	0.66	16
13–14 years	adults	16	0.78	0.66	13
14–15 years	adults	12	0.78	0.66	10
15–16 years	adults	10	0.78	0.66	8
16–17 years	adults	7	0.78	0.66	6
17–18 years	adults	6	0.78	0.66	5
18–19 years	adults	5	0.78	0.66	4
19–20 years	adults	4	0.78	0.66	3
20–21 years	adults	3	0.78	0.66	2
21–22 years	adults	2	0.78	0.66	2
22–23 years	adults	2	0.78	0.66	2
23–24 years	adults	1	0.78	0.66	1
24–25 years	adults	1	0.78	0.66	1
25–26 years	adults	1	0.78	0.66	1
26–27 years	adults	1	0.78	0.66	1
Total eggs produced without breeding by yearlings					884

[1]We assumed that nestlings were banded on the average halfway between hatching and fledging. Since nestling survival from hatching to fledging averaged 0.85, survival up to banding was calculated as 0.92.
[2]The proportion of total pairs breeding at Rochester was 0.66 during the 10-year period 1966–1975.
[3]Mean clutch size at Rochester was 2.43 eggs during the 10-year period 1966–1975.
[4]Calculated as mean proportion required to balance life equation.

The Role of Movements in Population Fluctuations

We concluded earlier that ingress and egress contributed significantly to the observed changes in horned owl numbers at Rochester (Table 3). These changes largely paralleled a cyclic fluctuation of Snowshoe Hares, but with the owls declining 1 year later. When annual recruitment at Rochester is combined with estimated post-fledging survival, and ingress and egress are assumed to be in balance each year, a population fluctuation is generated which peaks 2 years later than actually observed, and is of much lower amplitude (Figure 2). This difference between observed and theoretical population trends would hold even if yearlings exhibited the same nesting rate as adults (Figure 2, calculation A). The difference in amplitude increases markedly with lower rates of yearling nesting, as illustrated in Figure 2 (calculation B) where the mean yearling nesting rate was taken to be 0.36 that of adults (i.e., 0.24/0.66; Table 7,

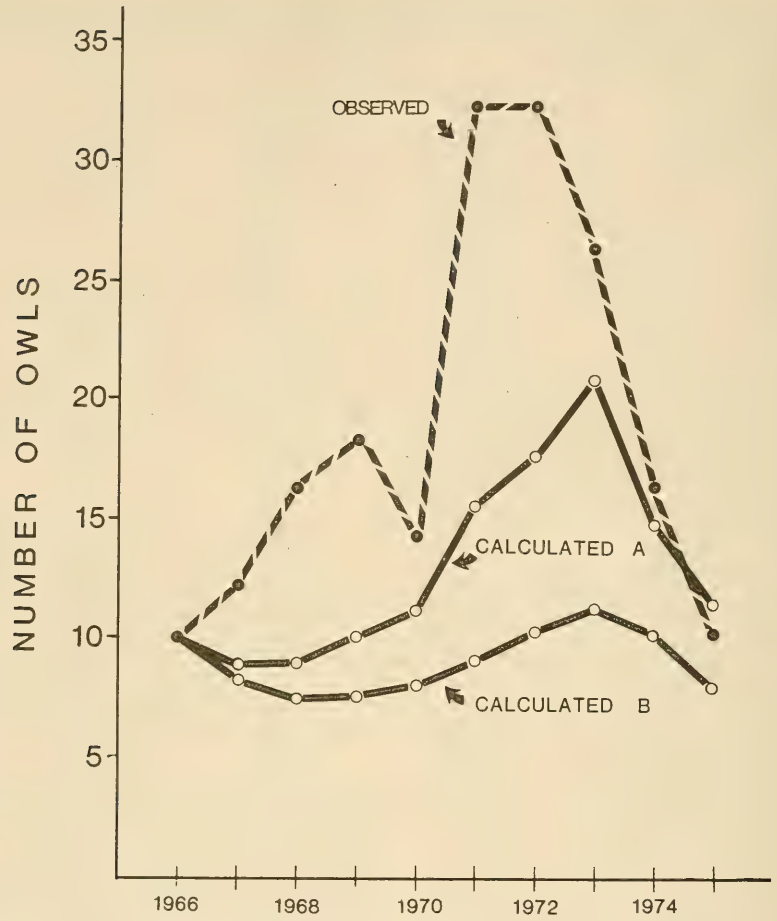

FIGURE 2. Comparison of observed and calculated trends in Great Horned Owl numbers at Rochester. Calculated trend A is based on observed recruitment of fledged young to the Rochester population, post-fledging survival estimated from regional banding data, and the assumption that yearlings and adults breed with the same frequency. Calculated trend B assumes that the mean frequency of yearling breeding is 0.36 that of adults (see text). The difference between the observed trend and each of the calculated trends is a function of ingress and egress.

column 5). Amplification of numerical trends on the study area was caused by a net ingress of at least 25 individuals during the 1966–1971 increase period, and a net egress of 15 individuals during the 1972–1975 decline (Table 3). Egress of between four and nine individuals from 1972 to 1973 was primarily responsible for the initial population decline.

If the foregoing analysis of horned owl population dynamics at Rochester is generally descriptive of Boreal Forest populations, then the question naturally arises as to the fate of emigrants during decrease years, and the source of immigrants during increase years. Dispersal rates are higher and dispersal distances longer during the population decline as demonstrated by band recoveries (Adamcik and Keith 1978). The tendency for unusual numbers of northern horned owls to occur in southern Canada and the United States following Snowshoe Hare declines in the Boreal Forest has long been noted (Swenk 1937; Spiers 1939), but not quantified. Adamcik and Keith (1978) found that 68% of the 19 band recoveries from dispersing horned owls (movements $>$ 25 km) were to the south in years of population increase, and a similar 69% of 42 recoveries in decrease years. On the other hand, Houston (1978) examined 209 returns from his

bandings in Saskatchewan and showed that 35 of 36 individuals moving over 240 km had travelled to the southeast. Thirty-one of the 35 were recovered in years of population decline. Ninety other recoveries of owls which had moved 10 to 240 km yielded no evidence of directionality.

Dispersal among the majority of horned owls thus seems to be essentially random in all years, but during periods of population decline there is a cohort which does move well to the south and hence out of the Boreal Forest ecosystem. That none of Houston's owls which had moved over 240 km to the southeast were recovered during May–August suggests that even these long-range dispersers probably return north in spring and summer as do wintering Snowy Owls (Keith 1964).

We therefore believe that most birds which egressed from the Rochester study area settled where food resources were sufficient to support them, and perhaps in some cases to permit nesting. The most likely locations would be on agricultural lands lying immediately south of the forest and its parkland fringe. Food would probably not be critical in the north during any summer, and it is quite possible that non-nesting individuals wander throughout the forest zone in those summers when hares are scarce. We feel confident, however, that if present, such non-nesters were also non-territorial at Rochester.

The territorial immigrants which appeared at Rochester as the hare population rose toward its cyclic peak could have come from a wandering cohort of non-territorial individuals wintering outside the Boreal Forest, and/or from territorial residents of agricultural land to the south, some of which had earlier dispersed from the forest zone when hares had become scarce. We think it much less likely that the apparent immigrants were in fact present all along, and only became territorial as hares became increasingly abundant.

Territoriality as a Factor Limiting the Great Horned Owl Population at Rochester

Territoriality in avian populations may space and/or limit numbers of individuals (Brown 1969; Klomp 1972; Newton 1976), and it is well documented among breeding populations of Great Horned Owls (Baumgartner 1939; Craighead and Craighead 1956, p. 269; Smith 1969). McInvaille and Keith (1974) felt that horned owls at Rochester were spaced but not limited by territoriality, since between 1967 and 1971 (years of hare population increase) the distribution of nests remained significantly regular, but the density of the territorial pairs rose almost threefold.

In 1972, however, the density of territorial pairs on the Rochester area failed to increase (Table 2). Hares were declining at that time but still abundant relative to the owls' requirements, as evidenced by: (1) 100% of the resident pairs producing and incubating a clutch, and (2) food biomass supplied daily to tethered young (Table 6) being similar to that during the two previous years. There had been a net ingress (and accompanying increase in owl density) in earlier years such as 1967 and 1968 when hares were far less abundant than in 1972. It therefore seems to us that territoriality may have prevented a further rise in owl density in spring 1972, and thus may have actually begun to limit the study area population 1 year earlier when its observed density was identical.

The peak breeding density at Rochester of one horned owl pair/10.1 km^2 was still below that reported from some other areas: 1/1.3 km^2 in Kansas (Baumgartner 1939); 1/6.5 km^2 in Utah (Smith 1969); and 1/7.8 km^2 in Wyoming (Craighead and Craighead 1956, p. 215). This suggests to us that maximum densities are not solely determined by an innate territoriality, but more likely by territoriality combined with, or modified by, food supplies and perhaps other factors in regional environments.

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Population Size and Structure of Four Sympatric Species of Snakes at Amherstburg, Ontario

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Populations of *Thamnophis butleri, T. sirtalis sirtalis, Storeria dekayi dekayi*, and *Elaphe vulpina gloydi* were studied in an abandoned quarry site in extreme southwestern Ontario. Estimates of population size for the 40-ha study area, based on various census techniques, are 900 *T. butleri*, 23 snakes/ha; 150 *T. sirtalis*, 4 snakes/ha; 550 *S. dekayi*, 14 snakes/ha; and 50–120 *E. vulpina*, 1.3–3.2 snakes/ha. *Thamnophis sirtalis* and *S. dekayi* were confined to small subsections of the main study area and within their actual area of occurrence had densities of 20 and 70 snakes/ha respectively. The relatively high density of snakes in the study area is thought to be related to abundant food, cover and denning sites. Sex ratios and size frequency distributions are described for all species, and brood size and percentage of gravid females are given for *T. butleri*. For all species, the proportion of young of the previous year was small, and the size distributions were strongly skewed toward adult size classes.

Key Words: *Thamnophis butleri, Thamnophis sirtalis sirtalis, Storeria dekayi dekayi, Elaphe vulpina gloydi*, population size, sex ratios, size classes, population densities, brood size, Amherstburg, southwestern Ontario.

Although some qualitative assessments have been made concerning changes in status of Canadian snakes (i.e., Logier 1957; Cook 1970; Rivard 1976; Pendlebury 1977; unpublished manuscripts by C. A. Campbell for Ontario Ministry of Natural Resources 1975, University of Western Ontario 1977, and Canadian Wildlife Service 1977), few quantitative estimates of population size or structure now exist. The only published estimates of Canadian snake populations known to the authors of this paper are for certain dense local aggregations of the Red-sided Garter Snake (*Thamnophis sirtalis parietalis*) utilizing karst hibernacula in the Interlake district of Manitoba (Gregory 1974, 1977; Aleksiuk 1977). For the 14 taxa of snakes (including 10 species) represented as rare or endangered in Canada by Cook (1970), there are no published estimates of size of local populations. Such quantitative estimates are important to the conservation of animal populations, since before effective management programs or protective measures can be undertaken, geographical distributions, demographic characteristics, and various other aut-and syn-ecological relationships must be described, so that action can be based on sound knowledge of the organisms concerned.

The purpose of the present report is to describe the population sizes and structure of four sympatric species of snakes at a site near Amherstburg, Ontario. Two of these species, the Butler's Garter Snake (*Thamnophis butleri*) and the Eastern Fox Snake (*Elaphe vulpina gloydi*), have been considered as rare or endangered in Canada by Cook (1970). The other two species, the Eastern Garter Snake (*Thamnophis sirtalis sirtalis*) and the Northern Brown Snake (*Storeria dekayi dekayi*), are widespread and common but are also dealt with in this study because little demographic data exist for Canadian populations of these species, and because interactions may occur between them and the two less common species with which they are sympatric. Other aspects of the ecology of sympatric snakes at the Amherstburg site, such as movements and distribution, are under study.

Study Area

Located approximately 2.4 km northeast of Amherstburg, 42°07′N and 83°05′W, in Anderdon Township of Essex County, Ontario, the study area is approximately 40 ha in extent. The substrates are calcareous (pH 7.6–7.8) throughout the area and vary from limestone pavement and coarse limey gravel to fine-textured calcareous clay-loam. The western portion of this area is comprised of an old limestone quarry that is relatively high, rocky, and irregular in topography. The lower eastern portion includes abandoned industrial and agricultural lands.

The quarry has been abandoned for at least 15 years, and the agricultural and industrial sectors for 5 years. Cottonwood (*Populus deltoides*), hawthorn (*Crategus mollis*), dogwood (*Cornus drummondii*), sumacs (*Rhus typhina* and *R. glabra*), and choke cherry (*Prunus virginiana*) have partially colonized the landscape, but extensive open areas exist, dominated in the drier parts by *Poa compressa* and elsewhere by other grasses and forbs (*Poa pratensis, Dactylis glomerata, Phleum pratense, Festuca pratensis, Daucus carota, Solidago nemoralis, Melilotus alba, Fragaria virginiana, Pastinaca sativa,* etc.). Periodically wet areas are dominated by *Puccinellia distans* while some permanently wet areas in the eastern part of the study have dense stands of cattail (*Typha latifolia* and *T. angustifolia*). Extensive rocky barren and semi-barren areas occur throughout the study area, and the cover of non-wooded areas varies from low (20 cm) and sparse to tall (1 m) and dense. Such variation frequently occurs over distances of only a few metres.

The study area is bounded on the west by the settling pools and service roads of Allied Chemicals Ltd., on the north by a railway and agricultural lands, on the east by oak-hickory woods (*Quercus alba, Q. macrocarpa, Q. borealis, Carya ovata*) and swampy lowlands, and on the south by agricultural lands. Since no snakes were found in these peripheral areas (comprising a larger study area of 64 ha), it appears that our 40-ha study area represents a more or less isolated "island" of optimal snake habitat.

Much of the site has been used as an unmanaged garbage dump by local residents, and numerous small fires, started to burn trash, have helped to maintain open grasslands. Litter from derelict buildings is common in the eastern section and piles of debris and rubble are characteristic of at least half of the area. Trails made by all-terrain vehicles and trail bikes are much in evidence in the quarry section.

Methods

All data presented here were gathered during a series of visits to the study area during the spring and summer of 1976. Some additional data relevant to Eastern Fox Snakes, collected in the spring of 1977, are also included. During the initial precensus and on each of the four census dates, sub-sections of the study tract were walked in a pre-determined order and virtually all snakes seen (including many hiding under cover) were captured for examination. Unmarked individuals were marked by clipping scales from the dorsal scale rows according to a numbering scheme that made it possible to distinguish individuals. This technique of marking is quite simple, and requires simpler surgery than the method of Blanchard and Finster (1933), who advocate the removal of complete subcaudal scutes, and yields more easily recognized marks than the method of Spellerburg (1977), who advocates the partial removal of subcaudal scutes. Our technique appeared to cause no discomfort to the snakes, and in captive Eastern Garter Snakes the marks were healed within 2 wk, but were clearly visible at the time of their release 1½ yr later. In addition, for all snakes captured and marked, the sex (determined by post-cloacal hemipenal distention in males), total length, gravidity (based on pronounced pre-cloacal body distention), color variation, characteristic markings, and various ecological data were recorded. Snakes born in 1976 were found only in the late summer censuses and were too small to be marked without possible injury, and are not included in the population size estimates or in the calculations of size distributions or sex ratios.

Population size estimates were made using the Petersen mark-recapture method within the context of multiple censusing. Statistically, the method requires that (1) the population is constant, with no mortality or recruitment during the experiment, (2) no immigration or emigration occurs, and (3) certain statistical assumptions are met concerning the randomness of capture and mixing of marked and unmarked individuals. Although these requirements are rarely fully satisfied in studies of animal populations, the method has nevertheless been effectively utilized in estimating local populations of snakes in the United States (Carpenter 1952; Fitch 1960, 1963, 1964, 1965, 1975). The technique is described in detail in the above references, and by Ricker (1975) and Smith (1974).

For each of the four census dates, a Petersen estimate of the population size was calculated

for three of the four species of snake. In addition, separate population estimates were made using four different multiple census calculations (i.e., the Schumacher, Schnabel, modified Schnabel, and Mean of Petersen Estimates). Ninety-five percent confidence intervals were also calculated for each population estimate. All of these calculations, and their relevant statistical assumptions, are summarized in detail by Ricker (1975).

Unfortunately, there were no recaptures of Eastern Fox Snakes during the 1976 censuses, and only one recapture was observed during the spring of 1977. Assuming that all Eastern Fox Snakes marked on the five 1976 sampling dates comprised a collective precensus, one can calculate a Petersen population estimate based on the single 1977 recapture. But an indirect estimate of the Eastern Fox Snake population can also be calculated, as follows. From Table 1, it may be calculated that a mean of 50 different Butler's Garter Snakes were captured on each of the five census dates, i.e., (61 + 69 + 49 + 48 + 23)/5 = 50. The mean estimate of population size for this species is given in Table 2 as 896. Thus, the probability of capturing a particular snake during any particular one of the census dates may be estimated as 50/896 = 0.0558. This probability is based on the same assumptions stated previously for the mark-recapture method in general. By similar means, the probability of capture for Eastern Garter Snakes is established as 14.4/158 = 0.0911, and for Northern Brown Snakes as 20.4/545 = 0.0374. The mean of these three estimates is (0.0558 + 0.0911 + 0.0374)/3 = 0.0614. Assuming that the probability of capturing a particular Eastern Fox Snake is roughly the same as that for the other species, we can apply the average probability of capture (0.0614) to Eastern Fox Snakes. This is done by multiplying the average number captured by the inverse of this probability in order to calculate a first-order approximation of the population size.

Observations and Discussion

Petersen estimates of the population sizes of three of the four species of snake on each of the four census dates are summarized in Table 1. The large standard errors are mainly due to relatively low recapture percentages.

Table 2 gives the multiple census population estimates for three species of snake. These four population estimates each involve somewhat different statistical assumptions and have different modes of calculation. Each calculation is based on an integration of the data from all four census dates presented in Table 1. Where population estimates at various dates are quite different from each other and the number of censuses in the multiple census is low (both of which are factors in our data), the 95% confidence interval can be quite large. High variation in population estimates of snake populations have also been reported in other snake census studies (i.e, Fitch 1960, 1963, 1975; Gregory 1974, 1977). Fitch (1975) considered this high variability to be an inescapable feature of mark-recapture censuses involving snakes because of low recapture success and the secretive behavior of most

TABLE 1—Population estimates (Petersen calculation) for four species of snakes on four 1976 census dates. H = number handled; R = number recaptured; Est. = population estimate

	Butler's Garter Snake (*Thamnophis butleri*)				Eastern Garter Snake (*Thamnophis sirtalis*)				Northern Brown Snake (*Storeria dekayi*)				Eastern Fox Snake* (*Elaphe vulpina*)			
Date	H	R	Est.	SE	H	R	Est.	SE	H	R	Est.	SE	H	R	Est.	SE
14 May**	61	—	—	—	15	—	—	—	15	—	—	—	3	—	—	—
30 May	69	6	702	±274	14	1	210	±56	25	1	375	±367	6	0	—	—
15 June	49	6	1013	±387	15	4	105	±45	22	3	286	±153	3	0	—	—
10 July	48	5	1603	±679	16	3	208	±108	33	2	957	±656	2	0	—	—
24 July	23	9	537	±140	12	4	156	±64	7	1	623	±577	2	0	—	—
Mean ± SD			964	±470			170	±50			560	±300			—	—

*See text for Petersen estimate based on 1977 recapture.
**Precensus date.

TABLE 2—Multiple census population estimates for three species of snakes. Four methods of calculating population size are summarized, based on four 1976 census dates

Method of population size estimate calculation	Butler's Garter Snake (*Thamnophis butleri*)		Eastern Garter Snake (*Thamnophis sirtalis*)		Northern Brown Snake (*Storeria dekayi*)	
	Population size	95% confidence interval	Population size	95% confidence interval	Population size	95% confidence interval
Schumacher	872	220 to 1922	159	63 to 484	610	96 to 1229
Schnable	890	220 to 2317	157	63 to 327	539	96 to 987
Modified Schnabel	857	593 to 1285	144	85 to 268	471	251 to 943
Petersen mean	964	220 to 1904	170	70 to 270	560	96 to 1160
Mean of four different estimates	896		158		545	

snakes. He nevertheless noted that, although the mark-recapture method does not provide a precise measure of population size, it does provide better information in most cases than direct or relative (i.e., snakes seen or caught per man-hour) counts, and at least indicates the order of magnitude of the population size.

Table 2 shows that the approximate population size of Butler's Garter Snake is 900 (23 snakes/ha), Eastern Garter Snake 150 (4 snakes/ha), and Northern Brown Snake 550 (14 snakes/ha). But both Eastern Garter Snakes and Northern Brown Snakes were localized in the mesic to wet eastern parts of our study area (approximately 7–8 ha), so that the effective population densities of these species within their areas of occurrence are closer to 20 snakes/ha and 70 snakes/ha, respectively.

The Eastern Fox Snake population can only be crudely estimated by the mark-recapture method because there was only one recapture. The Petersen population estimate based on this recapture is 128 snakes (SE = 120, density = 3.2 snakes/ha). The large standard error is largely a result of the single recapture. Rivard (1976) also noted very low recapture success with Eastern Fox Snakes in a study at Point Pelee, Ontario. An indirect first-order approximation of the Eastern Fox Snake population (based on an average probability of capture of the other three species sympatric at this site, and the assumption that the Eastern Fox Snakes exhibit a similar probability) is 52 (1.3 snakes/ha).

Carpenter (1952) calculated densities of 24.2 and 7.2 snakes/ha for Eastern Garter Snakes and Butler's Garter Snakes, respectively, at a site in Michigan where they were sympatric, while Fitch (1965) observed densities of Eastern Garter Snakes that ranged from 2.2 to 10.9 snakes/ha from 1956 to 1963 at a site in Kansas. Gregory (1977) calculated population sizes of Red-sided Garter Snakes at an intensively utilized denning site in Manitoba that ranged from 2056 to 5347 at various times from 1969 to 1973. He did not express any of his populations on a density basis. All of these authors considered their study sites to be areas of locally high snake populations. R. J. Planck (1977, unpublished report to Department of Supply and Services, Ottawa) reported total populations of Butler's Garter Snakes at a site (apparently 16 ha) near the Windsor airport, Ontario which varied from 55 to 1414 (mean = 455, SD = 457), based on five sampling dates in 1976.

The calculated Eastern Fox Snake densities at our site can only be compared to densities of the congeneric Black Rat Snake (*Elaphe obsoleta*) studied in Kansas by Fitch (1964), where densities of 4.2 snakes/ha were calculated during the period of relatively high abundance following the seasonal appearance of young snakes, while densities of 2.1 snakes/ha were noted at other times of the year. Fitch considered his study locale to be an area of high density for this species. We are unaware of any published population estimates to which our data on Northern Brown Snake can be compared.

The relative abundance of snakes at the Amherstburg site is believed due to some combination of (1) good cover provided by the numerous flat boards, pieces of metal, discarded mattresses, and miscellaneous other

scattered items that were found throughout the study area; (2) the apparent abundance of suitable food resources (i.e., an abundance of earthworms, amphibians, and small mammals); and (3) the probable presence of hibernacula in rocky parts of the quarry, in numerous piles of debris, or in foundations of derelict buildings.

Table 3 summarizes data on sex ratios and total length. The ratio of males to females in Butler's Garter Snake and the Eastern Garter Snake approximates 1, while for the Northern Brown Snake we found twice as many females as males, and for the Eastern Fox Snake there were approximately twice as many males as females. Fitch (1965) found the proportion of male snakes to be 0.53 for Eastern Garter Snakes at a site in Kansas, and he noted that this ratio varied seasonally, with relatively more males than females being present in his fall samples relative to his spring-summer samples. Gregory (1977) found the proportion of males in Red-sided Garter Snakes ranged from 0.52 to 0.65 at a site in Manitoba. Planck (*op. cit.*) found the proportion of males of Eastern Garter Snakes and

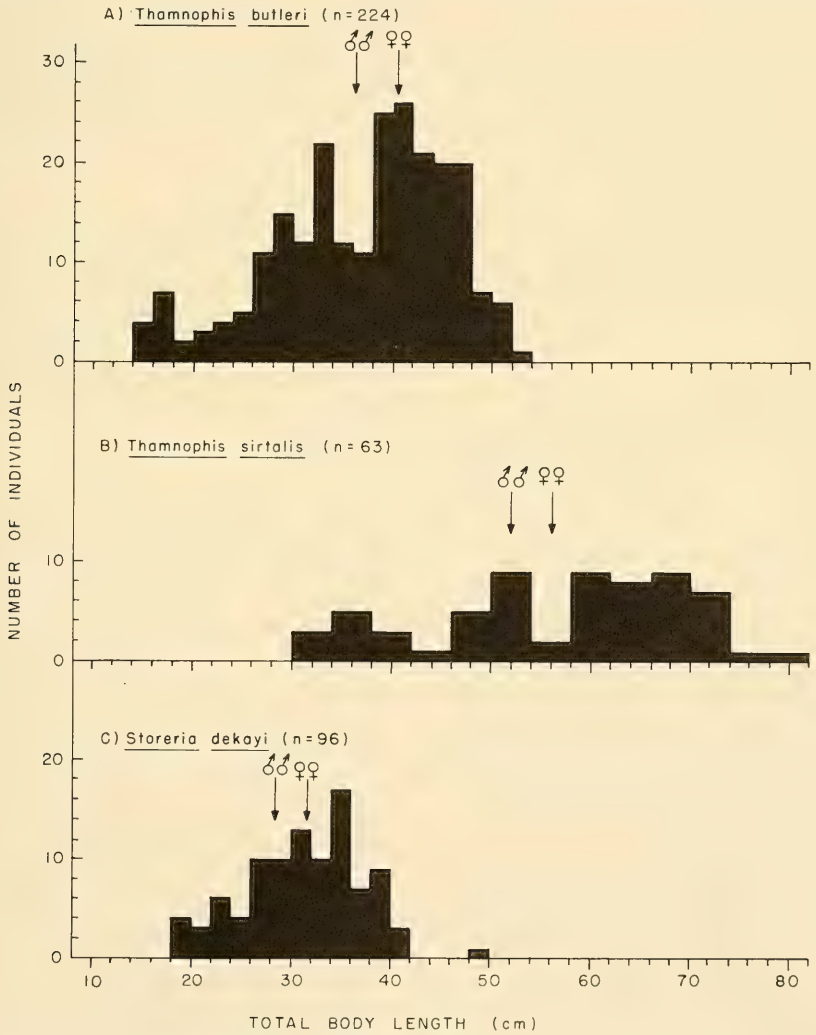

FIGURE 1. Size frequency distributions for three species of snakes from the Amherstburg, Ontario study site. The mean sizes of males and females are indicated. A, Butler's Garter Snake (*Thamnophis butleri*); B, Eastern Garter Snake (*Thamnophis sirtalis sirtalis*); C, Northern Brown Snake (*Storeria dekayi dekayi*).

TABLE 3—Sex ratios and mean total length of four species of snakes at the Amhertsburg study site

Species	No. examined	Proportion of males ± SE	Mean length, male (cm ± SD)	Mean length, female (cm ± SD)
Butler's Garter Snake (*Thamnophis butleri*)	220	*0.555 ± 0.034	36 ± 7	40 ± 7
Eastern Garter Snake (*Thamnophis sirtalis*)	63	*0.495 ± 0.063	52 ± 12	56 ± 13
Northern Brown Snake (*Storeria dekayi*)	96	0.365 ± 0.049	29 ± 4	33 ± 6
Eastern Fox Snake (*Elaphe vulpina*)	28	0.680 ± 0.089	102 ± 20	110 ± 25

* = Not significantly different from male: female ratio of 1.0 ($P < 0.05$).

Butler's Garter Snake from sites in southwestern Ontario to be 0.38 and 0.45, respectively. Rivard (1976) found male proportions for Eastern Fox Snakes ranging from 0.41 to 0.86, with an overall proportion of 0.51 at a number of sites in southwestern Ontario.

Mean total length of females was slightly longer than that of males for all species, although there was, of course, very considerable overlap between the two sexes, and variation was large. Figure 1 shows that the length-frequency distributions for three species are skewed toward adult sizes. For all species, the proportion of young born the previous year in the population samples was quite small (less than 5%), except for the late summer censuses of Butler's Garter Snake, when up to 30% of the individuals handled were recently-born young. The latter observation of low proportion of yearlings in the spring-summer censuses could have resulted from some combination of high infant mortality, or the possibility that yearlings were proportionately under-represented in the census owing to behavioral difference between yearling and adult snakes. Carpenter (1952) made similar observations on this matter for Eastern Garter Snakes and Butler's Garter Snakes at a site in Michigan.

In each of the three common species handled in our study, about 65% of the adult females (more than one year old) were obviously gravid.

Brood size was determined for the Butler's Garter Snake. Six females that were retained in captivity had broods of 4, 7, 9, 10, 10, and 11. The largest broods were from females with total lengths of 54.5 cm (11 young), 54.5 cm (10 young), and 46.0 cm (10 young). Wright and Wright (1957) cite brood size of Butler's Garter Snake ranging from 4 to 16, with an average of 9. The proportion of stillborn young or young with rapidly fatal birth defects was 5%.

Acknowledgments

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Distribution of Salamanders of the *Ambystoma jeffersonianum* Complex in Ontario

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Weller, W. F., W. G. Sprules, and T. P. Lamarre. 1978. Distribution of salamanders of the *Ambystoma jeffersonianum* complex in Ontario. Canadian Field-Naturalist 92(2): 174–181.

New distributional data on the four species of salamanders of the *Ambystoma jeffersonianum* complex in Ontario show that the ranges of *A. tremblayi, A. platineum,* and *A. jeffersonianum* are more extensive than had previously been known. Bruce, Brant, Lincoln, and Russell Counties and Muskoka District are added to the previous range of *A. tremblayi; A. platineum* is newly reported from Wentworth, Halton, York, and Northumberland Counties as is *A. jeffersonianum* from Wentworth and Halton Counties. The two diploid species, *A. laterale* and *A. jeffersonianum,* occupy different habitats and are almost always allopatric. One possible case of diploid hybridization is discussed.

Key Words: *Ambystoma jeffersonianum* complex, range extensions, sympatric distributions, morphology, habitat descriptions, museum specimens.

The *Ambystoma jeffersonianum* complex consists of four salamander species (Uzzell 1964): two dioecious, diploid ($2n = 28$) forms, *A. laterale* and *A. jeffersonianum;* and two essentially all-female, triploid ($3n = 42$) forms, *A. tremblayi* and *A. platineum.* The triploids arose by hybridization of the diploid forms (Uzzell and Goldblatt 1967) and, as presently understood, reproduce gynogenetically. *Ambystoma tremblayi* usually mates with *A. laterale* males as does *A. platineum* with *A. jeffersonianum* males.

The history of the nomenclature of this complex has been presented by Uzzell (1964, 1967a, b, c, d), whose interpretation we follow here.

Although all four species are known from Ontario, much of the data is unpublished and many museum specimens have been incorrectly identified. We here draw together all existing data and re-examine museum specimens to present a synthesis of the taxonomic and distributional status of this complex in Ontario. The literature concerning the habitats of the diploid species of this complex is reviewed, and those from where Ontario specimens were taken are described.

Materials and Methods

Salamanders were examined from the National Museum of Natural History, Washington (USNM), the Royal Ontario Museum, Toronto (ROM), and the National Museum of Natural Sciences, Ottawa (NMC). Living individuals, collected from eight localities in southern Ontario in March and April 1974–1976, were deposited in the herpetological collection of the National Museum of Natural Sciences, Ottawa.

Snout–vent length (tip of snout to posterior angle of vent), total length, and internarial width (distance between external nares) were recorded for each specimen. To determine ploidy of living specimens, blood obtained by digit amputation was spread in a thin film on glass slides and allowed to dry. Erythrocyte nuclear area was determined by planimeter tracings of camera lucida drawings from these preparations, and longest nuclear diameter was measured using an ocular micrometer. The ploidy of a subsample of specimens, determined by the electrophoretic patterns of the blood plasma proteins, was used to establish an empirical relation between nuclear diameter and ploidy (Table 1). Thereafter a sequential sampling analysis of longest nuclear diameter (Wilbur 1976) was used to determine the ploidy of individual specimens. Because the nuclear membrane shrank less than the cell membrane during slide preparation, nuclear area was considered a better correlate of ploidy than was erythrocyte area. To permit comparisons with published results, however, erythrocyte area was calculated for the specimens using a regression relationship with nuclear area established from the subsample of animals.

Results

Ambystoma laterale

This species is widely distributed in Ontario from the international border to Favourable

TABLE 1—Confidence limits of erythrocyte nuclear diameters using a sequential sampling procedure for distinguishing diploid and triploid salamanders of the *A. jeffersonianum* complex. The identification of a diploid or a triploid specimen can be made with 99% confidence when the cumulative sum of nuclear diameters is either less than, or greater than the confidence limits, respectively. These values are presented herein since those of Wilbur (1976) do not satisfactorily distinguish diploid and triploid Ontario salamanders of this complex

Number of cells	Maximum cumulative sum of longest nuclear diameters (μm) for diploids *A. laterale* and *A. jeffersonianum*	Minimum cumulative sum of longest nuclear diameters (μm) for triploids *A. tremblayi* and *A. platineum*
1	13	19
2	26	32
3	39	45
4	53	58
5	66	71
6	79	84
7	92	97
8	105	111
9	118	124
10	131	137
11	144	150
12	157	163
13	170	176
14	183	189
15	196	202

Lake, Lake Nipigon, and James Bay in the north (Uzzell 1967b). Males of this species were identified from Brant and Carleton County museum specimens, and from Halton County living specimens on the basis of morphology and pigmentation (*cf.*, Weller and Sprules 1976).

Ambystoma tremblayi

This species has been reported in Ontario only from Halton County (Menzel and Goellner 1976), Frontenac County (Uzzell 1964), and Carleton County (Uzzell 1967d), shown by the hollow circles, west to east, respectively, in Figure 1.

We have examined seven Ontario salamanders of this complex that are in the U.S. National Museum. USNM 10830 is represented by one female from "Lucknow, Ontario," Bruce County (Figure 1, westernmost solid circle) that was identified as *A. j. jeffersonianum* (Cope 1889). It seems certain, however, that this specimen is triploid because its snout width falls between that of *A. jeffersonianum* and *A. laterale* females (Figure 2). Furthermore, the coloration and presence of the typical *A. laterale*-like spotting on the tail suggest that it is *A. tremblayi* rather than *A. platineum.*

USNM 4690 is represented by two specimens, not one as indicated by Cope (1889), that have been identified as *A. j. jeffersonianum* from "St. Catharine's, Canada." Both are female. One contains enlarged ovarian eggs; the other is immature, and cannot be identified on the basis of morphology. Cope (1889) identified the larger female (presumably) listed under USNM 4690 as *A. j. jeffersonianum* and four females from the same locality, two under USNM 4822 (not 4022 as published) and two under USNM 14471, as *A. j. fuscum.* With the exception of one individual under USNM 4822, all contain enlarged ovarian eggs. Because the two largest sexually mature individuals have a shorter snout–vent length than the shortest sexually mature *A. platineum* yet examined (73 mm, Uzzell 1967c; 69 mm, Weller, unpublished) and a wider snout than *A. laterale* females (Figure 2), it seems likely that they are examples of *A. tremblayi.* The other three mature specimens from Lincoln County seem also to be *A. tremblayi* rather than *A. laterale* on the basis of the relatively wide snout.

The preserved females from Brant, Carleton, and Russell Counties had museum labels identifying them as *A. laterale* and *A. tremblayi.* Those that have a longer snout–vent length than *A. laterale* have generally proportionally narrower snouts than *A. platineum* (Figure 2). The presence of *A. laterale* males in these populations reinforces the taxonomic status of these females as *A. tremblayi.*

Living individuals of *A. tremblayi* were collected from Muskoka District (Figure 1, solid circle east of Georgian Bay) and Halton County (Figure 3A) in southern Ontario. These, and the museum specimens, are typical of the species in relative tail length (Figure 4A). There appears to be no variation in erythrocyte size between *A. tremblayi* from Ontario and those from southern populations (Figure 4B).

These records extend the distribution of *A. tremblayi* to include five new counties or districts (Bruce, Brant, Lincoln, Muskoka, and Russell) and eight new localities in Ontario. The taxonomic status of USNM 10830 and of the mature female under USNM 4690 has been

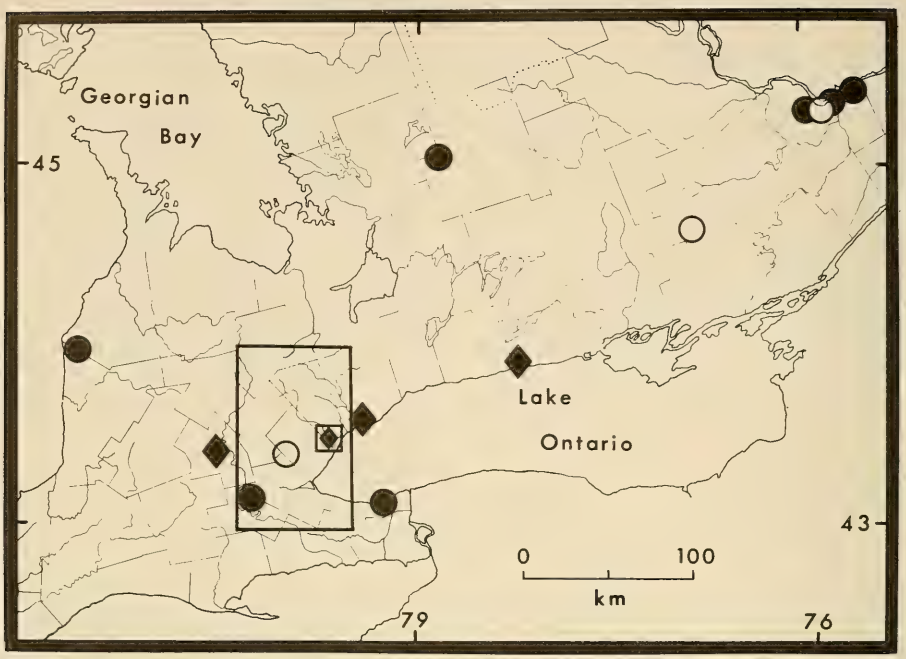

FIGURE 1. Distributional records of salamanders of the *Ambystoma jeffersonianum* complex in southern Ontario. Hollow symbols represent published records, solid symbols unpublished records. Circles refer to *A. tremblayi,* diamonds to *A. platineum*, and the square to *A. jeffersonianum.* Note the combination symbol of a hollow square and solid diamond.

changed from *A. j. jeffersonianum* to *A. tremblayi,* and of USNM 4822 and USNM 14471, from *A. j. fuscum* to *A. tremblayi.*

Ambystoma platineum

This species has been conclusively identified only from Waterloo County (C. A. Campbell, B. W. Menzel, and P. Pratt, unpublished data) and Peel County (W. F. Weller and B. W. Menzel, unpublished data) in Ontario (Figure 1, westernmost solid diamond and combination symbol, respectively).

We have examined four females of the complex from York County, "near Toronto" (ROM 3714–17), and one female from Northumberland County (ROM 122) that have museum labels identifying them as *A. jeffersonianum* (Figure 1, middle and eastern solid diamonds). All five specimens have females and intermediate between *A. tremblayi* and *A. jeffersonianum* females in snout width (Figure 2). It seems almost certain that they are examples of *A. platineum.*

Living specimens were collected from five localities in Peel, Halton, and Wentworth Counties (Figure 3A, solid circles). These specimens possess slightly longer tails and larger erythrocytes (Figure 4) than salamanders of *A. platineum* from southern populations.

Cope (1889) reported one record as *A. j. platineum* from "Moose River, British America," but the specimen (USNM 5368) has been lost or destroyed (R. I. Crombie, personal communication). In view of the known distribution of *A. platineum* summarized in this paper, it seems almost certain that USNM 5368 from the James Bay region of Ontario was not a specimen of *A. platineum.*

The results extend the distribution of *A. platineum* to include four new counties (Wentworth, Halton, York, and Northumberland) and six new localities in Ontario. The taxonomic status of ROM 3714–17 and ROM 122 has been changed from *A. jeffersonianum* to *A. platineum.*

Ambystoma jeffersonianum

Only one record from Canada, based upon male specimens from Peel County, Ontario (Weller and Sprules 1976), has been published (Figure 1, combination symbol).

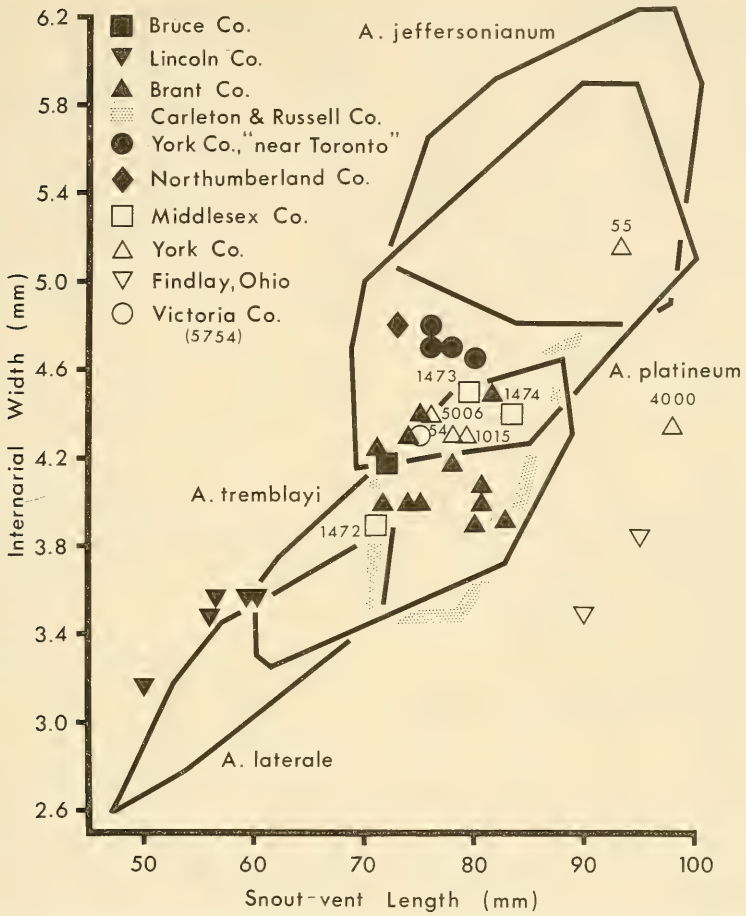

FIGURE 2. Relationship of internarial width to snout-vent length for preserved females of the *A. jeffersonianum* complex from museum collections. The margins of the clouds of points for the four species are based upon females of known identity presented in this paper and in Uzzell (1964). Solid symbols represent specimens for which the identity could be deduced; hollow symbols, those for which the identity could not be made. Numbers associated with hollow symbols refer to ROM catalogue numbers.

Females of this species were collected from five localities in Wentworth, Halton, and Peel Counties (Figure 3A, solid circles). They have slightly longer tails (Figure 4A) and larger erythrocytes than female *A. jeffersonianum* from southern populations (Figure 4B).

Males were collected from four localities in Wentworth, Halton, and Peel Counties (Figure 3B). They have considerably longer tails than do males from southern populations; the erythrocytes, however, are typical of diploids in size (Figure 4B). No triploid males were identified among Ontario specimens.

The distribution of *A. jeffersonianum* in Ontario is thus extended to include two new counties (Wentworth and Halton) and four new localities.

The precise taxonomic status of several Ontario females of this complex in the Royal Ontario Museum identified as *A. jeffersonianum* cannot be determined with certainty. Three specimens (ROM 1472, 1473, and 1474) are from Middlesex County, five (ROM 54, 55, 1015, 4000, and 5006) are from York County, and one (ROM 5754) is from Victoria County. On the basis of snout width alone, it is tempting to assign ROM 1472 either to *A. laterale* or *A. tremblayi*, and ROM 55 to either *A. jeffersonianum* or *A. platineum* (Figure 2). It is almost certain, however, that, except for ROM

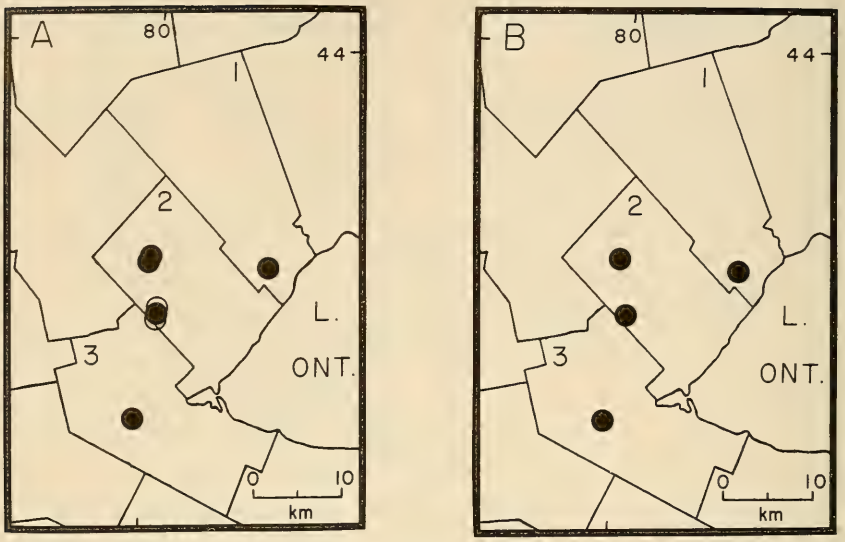

FIGURE 3. Distributional records for salamanders of the *A. jeffersonianum* complex in 1, Peel; 2, Halton; and 3, Wentworth Counties of Ontario from collections made by the authors. (A) Females: hollow circles, *A. tremblayi*; solid circles, *A. jeffersonianum* and *A. platineum*. (B) *A. jeffersonianum* males.

4000, the remaining specimens are triploid, i.e., either *A. tremblayi* or *A. platineum* (Figure 2).

The identity of ROM 4000 is an enigma. Because, for its length, it has a narrow snout (Figure 2), this specimen is atypical of any species in the complex. Uzzell (1964) examined two specimens from Findlay, Ohio (Figure 2) that were equally atypical. On the basis of the "numerous discrete light spots" on the venter, he concluded that these individuals closely resemble *A. tremblayi*. ROM 4000, on the other hand, because it is gray-brown in color and lacks any spotting, more closely resembles *A. jeffersonianum*. It seems unjustified, therefore, to assign this specimen to *A. tremblayi* solely on the basis of the similarity in snout width with those from Findlay, Ohio. ROM 4000 morphologically resembles *Ambystoma texanum*, because of its narrow snout width. It has, however, a greater snout–vent length and total length than *A. texanum* females (Smith 1961). The maxillary and premaxillary teeth are peg-shaped and do not hook inwards (cf, Tihen 1958, p. 7), and occur in a single row anteriorly. The one row of vomerine teeth is separated into three groups by breaks posterior to the internal nares, with the two lateral groups of these teeth extending beyond these nares. Although the tongue is partially decomposed, the lingual plicae apparently diverge from the posterior margin. With respect to these characters, ROM 4000 can be undoubtedly referred to the *A. jeffersonianum* complex, rather than to *A. texanum* (cf, Anderson 1967; Smith 1961, p. 24; Tihen 1958, p. 7). On a geographical basis, it is unreasonable to refer ROM 4000 to *A. texanum* since the latter species is known in Canada only from Pelee Island to extreme southwestern Ontario (Anderson 1967).

Discussion

The distributional data presented here provide evidence that the post-glacial dispersal of *A. tremblayi, A. platineum,* and *A. jeffersonianum* into southern Ontario has been more extensive than was previously documented. It is particularly interesting to note that *A. jeffersonianum*, a more southern species that is presumably more adapted to warmer climates (Uzzell 1964), occurs in Vermont and Ontario far north of the southern extent of the Wisconsin ice sheet.

All four species of this complex occur in both glaciated and unglaciated areas of northeastern North America and breed in both permanent and temporary bodies of water. An evaluation of the habitat descriptions from the literature suggests that the diploid species, and their

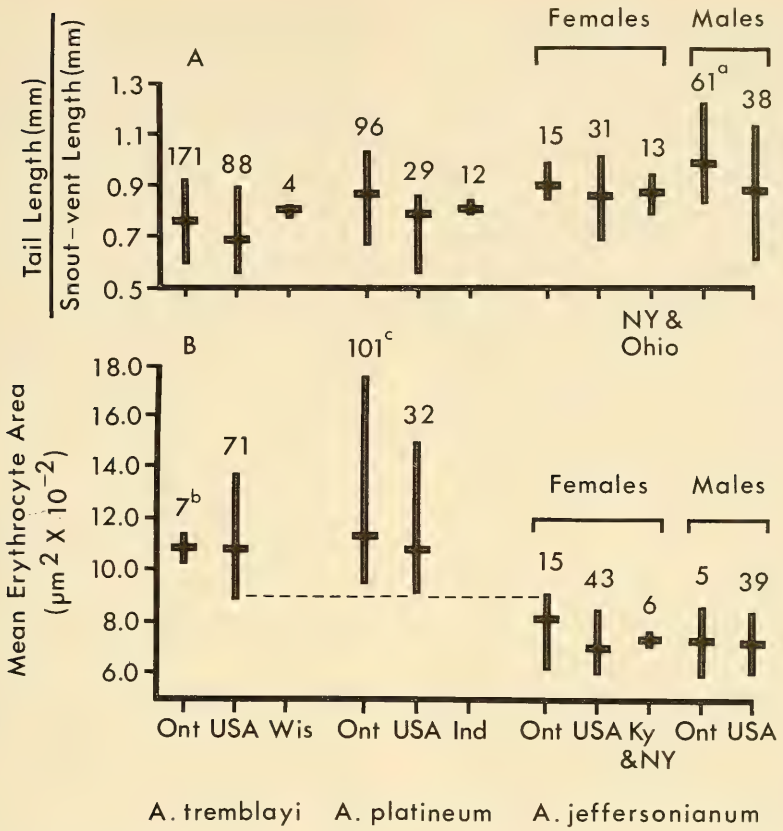

FIGURE 4. (A) Relation of tail length to snout–vent length, and (B) mean of individual salamander mean erythroctye area for adult salamanders of the *A. jeffersonianum* complex. Vertical lines show the range, horizontal lines the mean, and numbers the sample size. [a] signifies the inclusion of 50 males from Peel County reported by Weller and Sprules (1976), [b] the inclusion of one specimen from Halton County reported by Menzel and Goellner (1976); and, [c] the inclusion of four specimens from Peel County identified by W. F. Weller and B. W. Menzel (unpublished data). Specimens from Wisconsin, Indiana, New York, Ohio, and Kentucky are those reported by Menzel and Goellner (1976), and from USA, those reported by Uzzell (1964) from throughout the species' range.

associated triploid species, occupy different habitats. *Ambystoma laterale* and *A. tremblayi* generally occur in woodlots near open field ponds (Anderson and Giacosie 1967), near boggy and marshy areas (Bishop 1941, 1943; Bleakney 1954; Cook 1967; Menzel and Goellner 1976; Smith 1961; Wilbur 1972), near roadside ditches in sandy areas (Cook 1967; Gilhen 1974; Logier 1928), near backwaters of small lakes (Edgren 1949), and in poorly drained woodlots (Minton 1954, 1972; Smith 1961; Stille 1954). *Ambystoma jeffersonianum* and *A. platineum*, on the other hand, occur in comparatively undisturbed, well-drained forested areas (Anderson and Giacosie 1967; Creusere 1971; Douglas 1974; Minton 1954, 1972; Wacasey 1961).

The habitats from which we collected salamanders correspond with those reported in the literature. *Ambystoma laterale* and *A. tremblayi* were collected from flooded roadside ditches and grassy fields whereas *A. jeffersonianum* and *A. platineum* were collected from ponds in well-drained woodlots.

At one locality in Ontario (Halton County, 3.9 km south and 0.9 km east of Campbellville), we collected *A. jeffersonianum*, *A. platineum*, and one *A. laterale* male (NMC 17563 (1)) from a roadside pond situated at the edge of a well-drained forested slope. Although

A. laterale and *A. tremblayi* have been collected from nearby ponds and ditches, *A. jeffersonianum* and *A. platineum* were collected only from this pond. Although the electrophoretic patterns of blood plasma proteins of specimens collected do not suggest that *A. laterale* males successfully mate with *A. jeffersonianum* females in this Halton County pond, such a phenomenon cannot be ruled out. The electrophoretic pattern of one diploid individual taken with *A. tremblayi* from a pond in Waterloo County, Ontario, which resembles *A. laterale* in morphology, coloration and spotting, clearly shows two bands where one is expected (B. W. Menzel, personal communication). Although a final analysis has not been completed, it is conceivable that this individual is a diploid hybrid.

The proportionally longer tails of Ontario *A. platineum* and *A. jeffersonianum* could be an adaptation for survival at these northern latitudes. That a potential, metabolic energy source (i.e., lipids) is stored in the tail has been reported for *Batrachoseps attenuatus,* a west-coast North American plethodontid salamander by Maiorana (1976). She found that to maximize survival, adult salamanders will often regenerate broken tails rather than enlarge ovarian follicles if there is insufficient energy to do both.

Because of the difficulty in distinguishing members of this complex on the basis of morphology and pigmentation alone, we recommend that living, rather than preserved, specimens be submitted for identification. At least the ploidy of individuals can be determined on the basis of erythrocyte area (Uzzell 1964) or erythrocyte nuclear diameter (Wilbur 1976). The four species of this complex can be conclusively distinguished by the electrophoretic patterns of the blood plasma proteins (Uzzell and Goldblatt 1967).

Acknowledgments

We thank F. R. Cook, National Museum of Natural Sciences, Ottawa; R. I. Crombie, National Museum of Natural History, Washington; and E. J. Crossman, Royal Ontario Museum, Toronto for allowing us to examine and report on the specimens in their respective institutions. We are grateful to Craig A. Campbell, Waterloo, Ontario for allowing us to cite his unpublished record of *A. platineum* from Waterloo County, and to Bruce W. Menzel, Iowa State University for permitting us to cite and comment upon his electrophoretic findings. We thank F. R. Cook and Thomas Uzzell for reading the manuscript and offering valuable suggestions for its improvement.

Specimens Examined

Numbers refer to museum catalogue numbers, and, in parentheses, number of specimens.

A. laterale, preserved males: Brant Co., St. George, NMC 15057(17); Carleton Co., Harwood Plains, NMC 2720(1), NMC 6887(4), NMC 6888(6), NMC 6937(1), NMC 7685(8), NMC 7691(18), NMC 10926(1); Carleton Co., Bells Corners, NMC 8350(17), NMC 8354(5), NMC 8356(1), NMC 8357(1), NMC 8363(13), NMC 9215(2); Russell Co., Cumberland, NMC 9234(5), NMC 10951(1).

A. laterale, males examined alive: Halton Co., 3.7 km south and 0.9 km east of Campbellville, NMC 17563(1); Halton Co., 4.0 km south and 1.0 km east of Campbellville, NMC 17562(1); Halton Co., 4.1 km south of Campbellville, NMC 17560(4), NMC 17561(3).

A. tremblayi, preserved specimens (Figure 1, four westernmost circles): Bruce Co., Lucknow, USNM 10830(1); Brant Co., St. George, NMC 15057(12); Halton Co., 4.1 km south of Campbellville, NMC 17572(1); Lincoln Co., St. Catharines, USNM 4690(1), USNM 4822(2), USNM 14471(2). (Figure 1, four easternmost circles): Carleton Co., Harwood Plains, NMC 2720(1), NMC 6937(2), NMC 7685(2), NMC 7691(8), NMC 7831(3), NMC 10926(1); Carleton Co., Bells Corners, NMC 8357(2), NMC 8363(1); Carleton Co., Ottawa, NMC 2726(7); Russell Co., Cumberland, NMC 9234(66), NMC 10951(55). Examined alive (Figure 1, solid circle east of Georgian Bay): Muskoka Dist., 17.7 km south of Dorset, NMC 17575(1). Examined alive (Figure 3A), south to north, hollow circles): Halton Co., 4.1 km south of Campbellville, NMC 17569(3), NMC 17570(7), NMC 17571(4), NMC 17573(6); Halton Co., 3.7 km south and 0.9 km east of Campbellville, NMC 17574(9).

A. platineum, preserved specimens (Figure 1, west to east, solid diamonds, excluding combination symbol): Waterloo Co., Waterloo region, NMC 13464(1), NMC 13465(1); York Co., "near Toronto," ROM 3714–17(4); Northumberland Co., Port Hope, ROM 122(1). Examined alive (Figure 3A, south to north, solid circles): Wentworth Co., Mineral Springs, NMC 17585(28); Halton Co., 3.9 km south and 0.9 km east of Campbellville, NMC 17586(1), NMC 17587(2), NMC 17588(3), NMC 17589(3), NMC 17590(1), NMC 17591(1), NMC 17592(1), NMC 17593(3); Halton Co., 2.1 km south and 1.3 km west of Speyside, NMC 17584(7); Halton Co., 1.6 km south and 1.2 km west of Speyside, NMC 17583(13); Peel Co., near Streetsville, NMC 17576(10), NMC 17577(1), NMC 17578(2), NMC 17579(15), NMC 17580(5), NMC 17581(4), NMC 17582(9).

A. jeffersonianum, females examined alive (Figure 3A, south to north, solid circles): Wentworth Co., Mineral Springs, NMC 17594(1); Halton Co., 3.9 km south and 0.9 km east of Campbellville, NMC 17595(1), NMC 17596(1), NMC 17597(1); Halton Co., 2.1 km south and 1.3 km west of Speyside, NMC 17598(2); Halton Co., 1.6 km south and

1.2 km west of Speyside, NMC 17599(1); Peel Co., near Streetsville, NMC 17600(2), NMC 17601(1), NMC 17602(9).

A. jeffersonianum, males examined alive (Figure 3B, south to north): Wentworth Co., Mineral Springs, NMC 17564(4); Halton Co., 3.9 km south and 0.9 km east of Campbellville, NMC 17565(1); Halton Co., 1.6 km south and 1.2 km west of Speyside, NMC 17566(1); Peel Co., near Streetsville, NMC 15415(2), NMC 17458(1), NMC 17459(2), NMC 17567(1), NMC 17568(1).

Unidentified females: Middlesex Co., London, ROM 1472–74(3); York Co., vicinity of Toronto, ROM 54(1), ROM 55(1), ROM 1015(1), ROM 4000(1), ROM 5006(1); Victoria Co., Bobcaygeon, ROM 5754(1).

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Distribution of Giant Cow Parsnip (*Heracleum mantegazzianum*) in Canada

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Morton, J. K. 1978. Distribution of Giant Cow Parsnip (*Heracleum mantegazzianum*) in Canada. Canadian Field-Naturalist 92(2): 182–185.

The Giant Cow Parsnip, *Heracleum mantegazzianum,* occurs in many stations in southern Ontario and also in the Vancouver area. Its known distribution in southern Ontario is mapped. A native of the Caucasus and southwestern Asia, it was probably introduced into Canada from Europe as a garden plant and has escaped to become a potentially serious weed. Methods of control are possible by using existing knowledge of its life cycle and general biology. Characters that distinguish it from the similar *H. maximum* and *H. sphondylium* are its large size, the elliptic fruits and their broad oil canals. The plant is a cause of severe and painful blistering and dermatitis as a result of a phototoxic reaction of the sap when in contact with the skin.

Key Words: *Heracleum*, weeds, dermatitis, phototoxic, herbicides.

The Giant Cow Parsnip or Giant Hogweed (*Heracleum mantegazzianum* Sommier and Levier) is an umbelliferous plant which attains a height twice that of a man, with umbels reaching several feet across. I reported its occurrence in Canada in 1975 on the basis of plants found the previous year growing in and around Tara in the Sauble Valley of Bruce County in southern Ontario (Morton 1975). This record elicited a number of letters from naturalists who reported the presence of the species in other localities in Ontario. In particular, George Thomson drew my attention to a note on the occurrence of the species in the Keppel area (Owen Sound) which he put in the newsletter for January/February 1971 of the Michigan Botanical Club (Southeastern Chapter). These records, together with those resulting from a search for the species which I have made over the last two summers, indicate that it has attained a wide distribution in southern Ontario and may be spreading rapidly. It is also established on the other side of our continent, in Seattle, and has recently been reported from Vancouver (Kamermans 1977). The species is native in the mountains of the Caucasus and southwestern Asia but it was introduced into European gardens before the turn of the century for its impressive appearance. It soon escaped from cultivation and is now widely naturalized across Europe and in Britain. It was presumably introduced into Canada for similar reasons, for it is a most spectacular plant particularly when in flower in late June and July. Its introduction probably dates back many years, for George Thomson informs me that he recalls seeing the plant on the Bruce Peninsula in the late 1940s or early 1950s and C. L. Hitchcock (personal communication) has known of its occurrence in Seattle for 25 years.

The Giant Cow Parsnip usually grows in deep rich moist soils in semi-shade and is most frequently found along rivers and streams or planted in gardens. The center of its present distribution in Canada is the Bruce Peninsula southwards to Perth County and Waterloo Region, but it has spread as far east as Haliburton County and north to at least the tip of the Bruce Peninsula at Tobermory and possibly (unconfirmed report) Manitoulin Island. Figure 1 indicates the distribution of *H. mantegazzianum* in Ontario as known to me at the time of writing. Readers are asked to watch for the Giant Cow Parsnip on their travels. I shall be very interested to hear of further records for the species.

Though enormous size is its most ready means of identification, *H. mantegazzianum* may be confused with large specimens of our native Cow Parsnip (also known as Hogweed and Masterwort), *H. maximum* Bartr. (= *H. lanatum* Michx.). The fruit, however, is diagnostic in size and shape and in the width of the oil or resin canals (vittae) (see the accompanying photograph, Figure 2). Another useful character is the dark reddish-purple stem, and the spotting of the leaf-stalks and young stems with a similar color, each spot having a pustulate bristle. These bristles stick into the skin and break off to cause irritation. The stems and leaf-stalks of *H.*

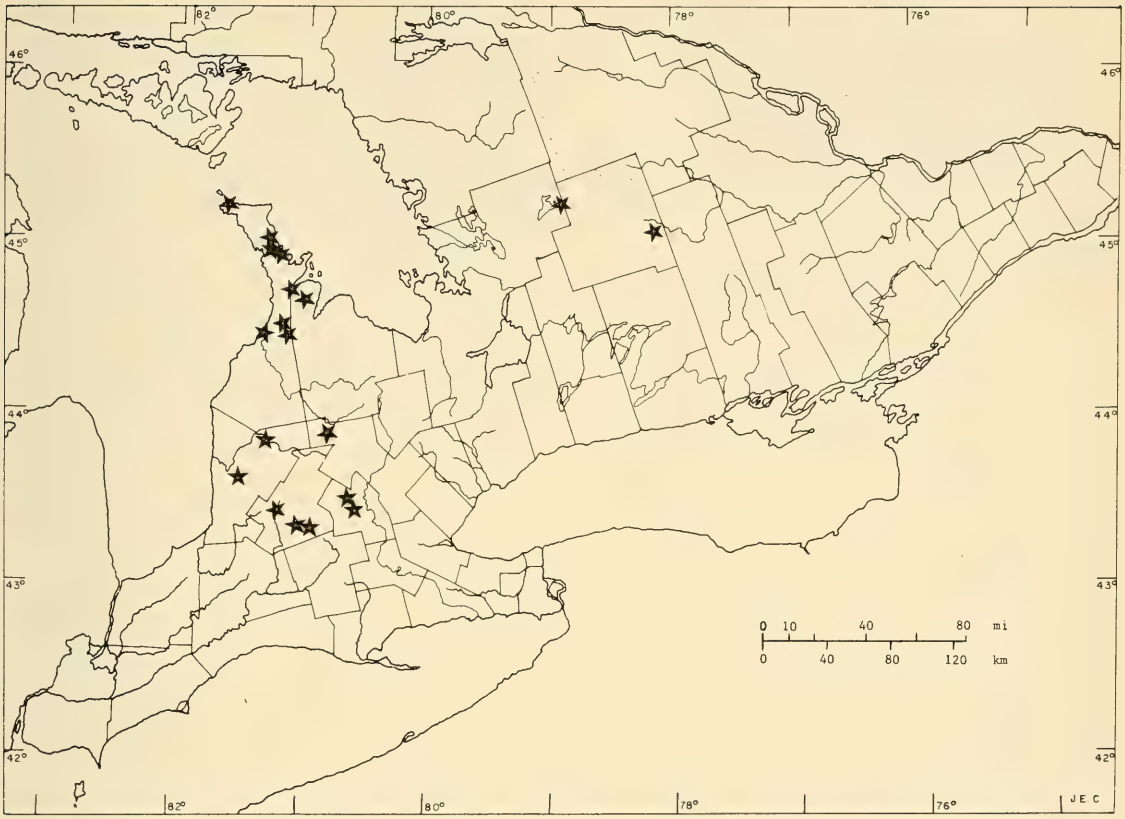

FIGURE 1. Distribution of the Giant Cow Parsnip in southern Ontario.

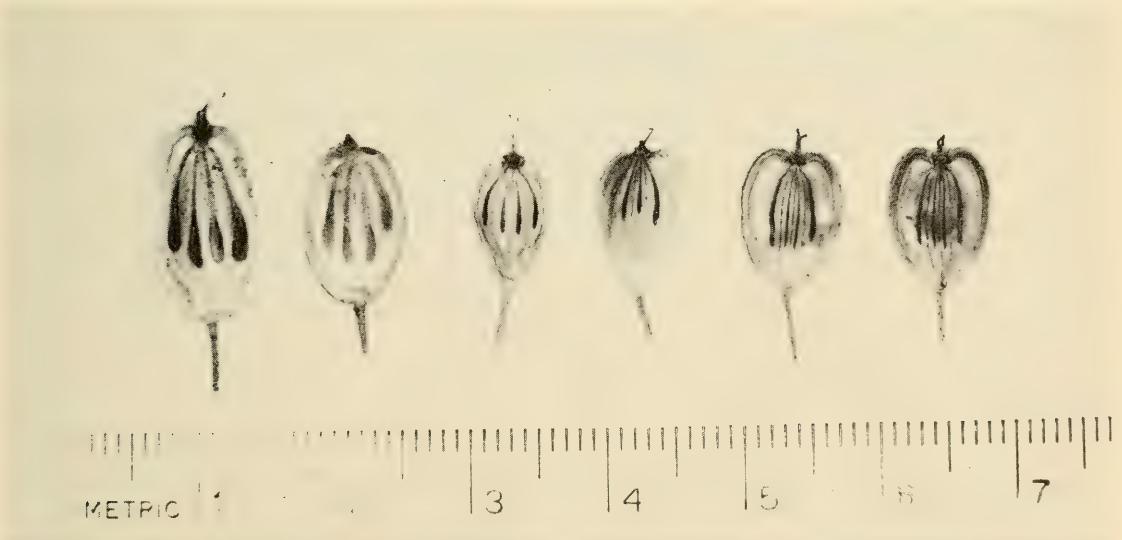

FIGURE 2. Fruits of species of Giant Cow Parsnip found in eastern Canada. Left pair, *H. mantegazzianum*; center pair, *H. maximum*; right pair, *H. sphondylium*.

maximum lack the spotting and the pustulate bristles though they often have scattered soft hairs. We have another species of Cow Parsnip in Ontario, *H. sphondylium* L. which is a rare alien weed introduced from Europe. It is usually smaller than either of the other species and has fruits similar to those of *H. maximum*. Its stems, leaves, and leaf-stalks have long, white, coarse hairs.

Though *H. mantegazzianum* is a very handsome, spectacular and even beautiful plant, it has the potential to become a serious weed, for in addition to having the irritating bristles which break off in one's skin, it exudes a clear watery sap which can cause severe blistering and a very painful dermatitis. I experienced the effects of the sap in July 1976 after collecting herbarium material of the plant at the height of its flowering season. The cut stems and leaf-stalks exude copious amounts of sap at this stage in the plant's development and a drop of this fell on the side of my leg. It was quickly removed but the next day a large and painful watery blister developed. It took two weeks for this to begin to heal and a red scar remained for several months. The hazards of contact with this plant attracted press comment in Britain in 1970 after many cases of blistering were reported from various parts of the country. A comment in the *Lancet* (4 July 1970) was that reaction to the sap is stimulated by exposure to the sun and that a permanent brown pigmentation of the skin often ensues. In the same year reports appeared in the *Wiarton Echo* (2 July and 17 September) of a child contracting blisters and being hospitalized after playing with the large bamboo-like stems of this plant from the Southhampton area of Ontario.

It is clear that the rapid spread of the Giant Cow Parsnip presents a potential hazard and if it continues control measures will, unfortunately, be necessary. I would caution anyone coming across the plant to avoid contact with the juices from the broken stems and leaves. The hazards are apparently greatest at the height of the growing season (June and July) when sap exudes freely from broken plants, and on hot sunny days when perspiration and sunlight accentuate the effect of the sap. Juices on the skin should be washed off immediately with copious amounts of water, or better still, soap and water, and a skin lotion of the sort used to relieve irritation and insect bites applied. Corticosteroid lotions or gels (not creams) may be the most effective method of treatment. Medical advice should be sought if there are signs of reaction.

The underground tuberous rootstock, rapid growth, and abundant seed-production of this plant make control or eradication difficult. The Giant Cow Parsnip is a perennial but it takes several years (four in plants grown experimentally at Waterloo) from germination of the seed to the production of the flowering shoot. It is probable that the plant is often monocarpic and dies after flowering and fruiting. This occurred with plants that I grew in cultivation, but examination of ones growing elsewhere suggests that the rootstocks may on occasion produce additional crowns after flowering, and these continue to grow. Though most of the herbicides in common use for the control of broad-leaved plants (e.g., 2,4-D, TBA, MCPA and dicamba) will kill the above-ground parts of the Giant Cow Parsnip they do not completely eradicate the persistent rootstocks. Successful eradication of the plants has been obtained by the use of 2,4-D acid in oil emulsion, and with a TBA and MCPA mixture (Drever and Hunter 1970). Spraying should be carried out early in the season when the leaves are green and actively growing, i.e., before flowering, and the plants should be thoroughly sprayed to ensure complete coverage. Control can be achieved also by cutting the plants down each year early in the growing season, but the rootstocks remain alive for many years when prevented from flowering and seeds in the soil will continue to germinate. In Europe effective control has been obtained by allowing cattle to graze in the area where the plants are growing. Apparently the trampling of the cattle not only knocks down the leaves and stems but also crushes the crowns of the rootstocks and this usually prevents further growth.

The fruits are large and split into two winged propagules each containing a seed. These are carried short distances by the wind. The principal natural mode of dispersal, however, appears to be by water, and flotation tests indicate that the fruits float in water for up to 3 days (Clegg and Grace 1974). The Giant Cow Parsnip frequently grows on river banks, hence

in times of flood, dispersal over distances of many kilometres can be expected. Human activities are doubtless an equally effective means of dispersal as fruits are introduced intentionally or accidentally. Inflorescences are often collected for decoration and seeds are sown in gardens. The seeds retain their viability for several years. Those that I have kept dry at room temperature were still viable after 7 yr. Hence even if the plant is eradicated from a locality it is liable to reappear, as seed lying dormant in the ground germinates. In view of the potential hazards of this plant, should it spread extensively in this country, further studies on its life history and on methods of control are clearly desirable.

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Notes

Morphology, Diet, and Parasitism in Quebec Black Bears

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Juniper, Ian. 1978. Morphology, diet, and parasitism in Quebec Black Bears. Canadian Field-Naturalist 92(2): 186–189.

Data on age classes, morphology, diet, and incidence of endoparasitism were obtained from 30 Black Bear (*Ursus americanus*) killed north of Montreal during spring and summer 1972. Male bears averaged younger than females (4.0 versus 6.7 years) and were larger by age class. The heaviest animal examined was a male of unknown age weighing 154.0 kg. The heaviest female recorded was 5 years old and weighed 121.5 kg. Vegetation was shown to be of primary importance in the diet of bears examined, while animal remains including fish and a trace of insects were of secondary importance. The incidence of endoparasitism was low, with four specimens infected by *Ascaris*, two with *Coccidia*, and one with *Diphyllobothrium*. No evidence of *Trichinae* was discovered.

Key Words: Quebec, Black Bear, morphology, diet, parasitism.

There are few data on the physical characteristics and seasonal diet of the Black Bear (*Ursus americanus*) in the Province of Quebec. The incidence of endoparasitism in Quebec bears is somewhat better known (Fréchette and Panisset 1973), but this aspect of Black Bear biology remains incompletely described. The present project was designed to provide information on all of the above.

Study Area

Bears for the study were collected in two areas north of Montreal (Figure 1). The first area begins some 40 km north of Mont Laurier and covers about 650 km² of public land, 114 km² of which is leased by the Quebec government to a licensed outfitter, J. B. Scott Incorporated, the remainder being leased to private hunting and fishing clubs. The topography is low and rolling. The forest type is basically boreal.

The second area is located about 105 km north of Montreal in the south-central section of Mont Tremblant Provincial Park and covers about 1000 km². Rowe (1972) places this area within the Laurentian section of the Great Lakes – Saint Lawrence Forest region. It is a zone of transition to the boreal forest and is characterized by upland tolerant hardwoods with mixed woods and softwood found in the valleys. The topography is dissected and rugged. In both areas lakes and streams are common.

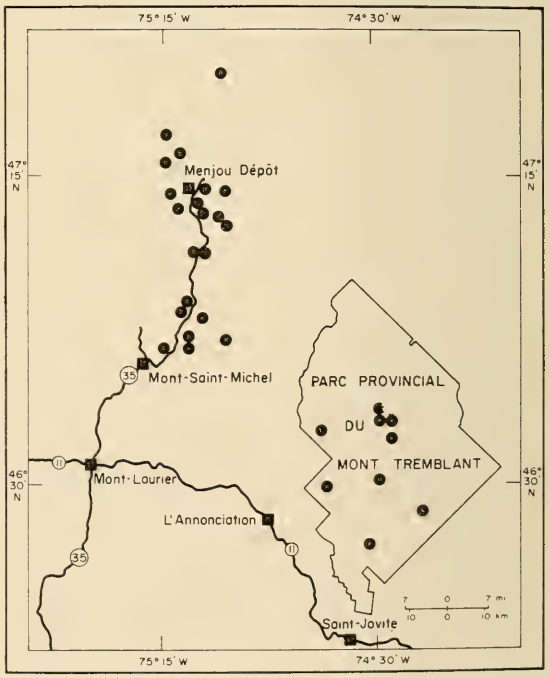

FIGURE 1—Map showing distribution of bear kill in the study area.

Materials and Methods

Data were obtained from freshly killed bears through the cooperation of a number of sport hunters during the spring of 1972. Also, a number of bears which became troublesome for campers in the park were judged undesireable and were destroyed by Department personnel. Advantage was taken of this situation to gather additional information.

Animals killed by hunters were examined at the hunting camp of J. B. Scott. Bears taken within the park boundaries were autopsied nearby at the Wildlife Management Service station at Sainte Faustin. The

date and location of each kill was recorded, the sex was determined, and weights, rounded to the nearest 0.5 kg, were obtained by means of platform scales. Total zoological lengths of the animals were measured to the nearest 5 mm with a steel-roll tape. When possible, the second or third premolar was extracted for age determination. The tooth was decalcified, sectioned, and stained to reveal the cementum layers (Stoneberg and Jonkel 1966).

Autopsies were performed as soon as possible after a kill. Stomach contents of bears were examined macroscopically and divided into four categories: plant, mammals/fishes, insect, and undetermined. Gross volumetric estimates for each category were made visually. A section of the diaphragm near the rib cage was removed and kept frozen until examined for *Trichinae* larvae. The intestines were removed, tied off, and preserved in a solution of 5% formalin and later examined for the presence of gastrointestinal parasites.

Results

Between 21 May and 26 August 1972, 30 bears were examined. Twenty-one of these were hunter-killed. The remaining nine were collected during the summer bear control program in Mont Tremblant Park. Table 1 records the ages, sex, weights, and total lengths.

Ages were determined for 23 bears. The youngest was a male yearling and the oldest a 12-year-old female. For seven bears the ages were not determined, but their weights and measurements were used to estimate their maturity. Six of the seven were considered to have been adults. The seventh, a male, was probably a yearling. No young-of-the-year were included in the sample. Males averaged younger than females for both regions. The mean age for males was 4.0 years (n = 16) and 6.7 years for females (n = 7). Bears from the park averaged 5.5 years as compared to 4.6 for the outfitter's sample.

The sex-ratio favored males (200: 100). Sport hunters killed twice as many males as females (14: 7). Six males and three females were taken from the park.

The weights of 30 bears were recorded. The heaviest animal was an unaged male weighing 154.0 kg. Bears of age class 5 averaged heaviest for both sexes. The data also showed that males of each class were heavier than females of the same age class.

The total lengths for 27 bears ranged from 1145 mm for a male yearling to 1830 mm for a male of age class 5. The longest female measured 1640 mm and was of age class 5.

Diet

The stomach contents of 30 bears were examined (Table 2). The stomachs of two specimens were empty, but the intestines of these animals contained food

TABLE 1—Mean weights and mean total lengths by sex and age of 30 Black Bears taken north of Montreal, Quebec, 21 May – 26 August 1972

Sector	Sex	Age class	Number	Weight (kg)	Total length (mm)
Outfitter	m	1	1	35.0	1145
	m	2	2	50.5	1285
	m	3	4	38.0	1310
	m	4	2	59.5	1505
	m	5	1	113.5	1830
	m	7	1	53.0	1500
	m	9	1	81.5	1625
	m	adult	2	81.5	1645
	f	4	1	43.5	1170
	f	5	2	91.0	1530
	f	6	1	55.5	1370
	f	12	1	59.5	1600
	f	adult	2	49.0	1405
Park	m	2	1	27.0	980
	m	4	1	65.5	1450
	m	5	1	104.5	1625
	m	7	1	84.0	1560
	m	yearling	1	28.0	NA
	m	adult	1	154.0	1725
	f	4	1	58.0	NA
	f	11	1	58.5	1485
	f	adult	1	49.5	NA

material. Of the remaining 28 stomachs, 24 each contained a predominance of green vegetation, and three each contained mostly animal remains. The stomach of one bear contained garbage only. No evidence of moose (*Alces alces*) hair was found in any of the stomachs or intestines examined during the study. The animal remains were identified as fish, meat from garbage dumps, and bait set out by hunters. Most fish remains were identified as doré (*Stizostedion vitreum*) and sucker (*Catastomus* sp.).

TABLE 2—Diet of 29 Black Bears from the area north of Montreal, 21 May to 26 August 1972

Food category	Frequency	% occurrence	% volume
Plants	26	86.6	70.9
Mammals/ fishes	21	70.0	24.6
Insects	1	tr.	tr.
Undetermined	5	1.7	4.3

Endoparasitism

The intestinal tract of each bear was examined for parasites (Table 3). The adult form of the nematode *Ascaris* sp. was found in two specimens, and eggs of the same species were isolated from two others. Two specimens contained the protozoon *Coccidia* spp. and the eggs of hookworm. *Diphyllobothrium ursi* was isolated from one other intestinal tract. No evidence of intestinal parasitism was reported from the remaining 23 bears. No evidence of *Trichinae* spp. larvae was found.

TABLE 3—The incidence of endoparasites in 30 Black Bears taken north of Montreal, Quebec, between 21 May and 26 August 1972

Parasite	Frequency	% occurence
Ascaris (adult or egg)	4	13.3
Hookworm (egg, sp. ?)	2	6.7
Diphyllobothrium ursi (adult)	1	3.3
Coccidia (adult)	2	6.7
Trichinae	0	0.0

Discussion

There was a preponderance of males and a lack of cubs in the hunter-killed portion of the sample, primarily because the outfitter discourages the killing of cubs and females with cubs. Bears taken from the park did not include young-of-the-year as females with cubs appeared to avoid the major camping areas. But a cub sex-ratio favoring males has been reported from other areas (Spencer and Howard 1966; Jonkel and Cowan 1971). Willey (1970) reported an average sex-ratio of 124 M: 100 F for bears taken by hunters in Vermont, 1963–1968.

The weights of Black Bears may vary appreciably during the year (Marks and Erickson 1966). Peterson (1966) mentions marked loss of weight in bear during early spring. Comparison of the weights of adult bears in this study with data from other regions (Peterson 1966; Marks and Erickson 1966; Anonymous 1968) suggests that the bears from the Quebec study area were lighter. Because most of the animals in the sample were taken in the spring and early summer, however, the weights obtained may represent minimums for the year. The total lengths of the bears examined compare favorably with those provided by Peterson (1966).

The Black Bear is protected from hunting within Mont Tremblant Park; therefore the higher average age for animals taken within the park as compared to that of hunter-killed bears is to be expected. The protection afforded maternal females by the outfitter's clients undoubtedly contributed to the higher average age for females as compared to males taken in this sector.

Most animals examined during the study were killed in late May or early June, a time coinciding with the peak calving period for moose in Quebec. Both sectors of the study area support substantial moose populations (Goudreault 1973, unpublished report, Wildlife Management Service, Saint-Faustin, Quebec). No moose hair in any of the alimentary tracts examined suggests that the Black Bear is not a major cause of newborn moose mortality within the study area.

The importance of green vegetation in the diet of the Black Bear has been reported for other regions (Tisch 1961; Hatler 1972). Spencer (1966), however, reported a high volume of animal food in the spring diet for bears in Maine. Both species of fish identified in the stomach contents of bears from the present study are spring spawners and usually congregate in rivers and streams during this period. A number of these fish were probably taken directly off the spawning beds.

The incidence of endoparasites found in the sample was not high. It is possible that the level of infestation rises as the summer progresses, but this is uncertain. Bears from this area may never be heavily parasitized. Sixty bears taken by hunters in Vermont in 1969 were examined for the presence of Trichinae (Willey 1970); only one was found to be infected. Jonkel and Cowan (1971) concluded that parasites and disease were not important in the Black Bears of Montana.

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Late Winter Bedding Practices of Moose in Mixed Upland Cutovers[1]

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Moose (*Alces alces andersoni*) bedding sites within five northern Ontario mixed upland cutovers were examined during January and February to learn more about criteria affecting the choice of bed sites. Significant ($P < 0.05$) differences in snow depths in the vicinity of bedding sites, the proximity of potential windbreaking coniferous cover, and meteorological records concerning prevailing winds during the study period indicated that moose were utilizing immature coniferous tree species as windscreens and perhaps found snow conditions in the lee of these windbreaks preferable for bedding. Coniferous cover was usually least prevalent in southerly directions at bedding sites indicating that moose chose sites for bedding that minimized windchill and maximized exposure to solar radiation.

Key Words: Moose (*Alces alces andersoni*), winter bedding, upland cutovers.

There has been little investigation into moose bedding sites since the work done by Des Meules (1965). Because adult moose may bed up to seven times a day (Franzmann et al. 1976) and the lack of suitable bedding sites may temporarily be a limiting factor in the utilization of winter range (Des Meules 1964), the collection of further data on moose bedding practices became a secondary objective of moose habitat investigations (McNicol 1976).

Study Area and Methods

Data were collected on five 10- to 15-year-old mixed upland cutovers located on or close to the Mott Lake Road, a private secondary timber haul road approximately 64 km northeast of Thunder Bay, Ontario.

Soils in the study area are thin basal tills often averaging only a few centimetres to 0.3 m in depth. Bedrock exposures are frequent, as are swamps or poorly drained areas. The topography of the area is

characterized by low gently rolling hills and by rocky ridge systems oriented in a northeast-to-southwest direction.

The study area was situated in the boreal forest biome. The coniferous species distribution in the area of study was black spruce (*Picea mariana*), 51.0%; white spruce (*Picea glauca*), 10.0%; balsam fir (*Abies balsamea*), 13.0%; and jack pine (*Pinus banksiana*), 26.0%. White birch (*Betula papyrifera*) and trembling aspen (*Populus tremuloides*) represented 12.0 and 13.0% respectively, of the total inventory of all species.

The mean annual precipitation is approximately 760 mm and during the winter season up to 203 cm of snow may fall, but average snow depths are approximately 76.0 cm.

Data were collected at each moose bed location encountered while we were following moose tracks (1–3 days old) on mixed upland cutovers during January and February 1975. These included snow depth and depth of bed beneath the snow's surface, direction of the most (and least) potentially effective windbreaking cover, the species composition of the cover and diameter at breast height, and snow depth 3.1 m from the bed site in the direction of the most as well as the least potentially effective windbreaking cover. "Cover" was arbitrarily defined as coniferous species that would provide a barrier to the wind.

On occasions when a snowfall had occurred after a moose bed was made, the depth of fresh snow in the bottom of the bed was deducted from the depth of bed measurement and all snow depth measurements. Where a moose bed was located in uneven snowcover, the depth of bed and snow depth at bed site measurements were an average of the greatest and least snow depth associated with the moose bed.

TABLE 1—Tree species used for cover at bedding sites and their diameter at breast height in the Spruce River Road cutovers, 13 January – 28 February 1975

Species	Frequency of occurrence at bed sites, %	Diameter at breast height range, cm
Balsam fir	52.0	2.5 – 7.6
Balsam fir + black spruce	15.1	2.5 – 10.2
Black spruce	6.8	7.6 – 10.2
Jack pine	23.3	2.5 – 7.6
Black spruce + jack pine	1.4	2.5 – 5.1
White spruce	—	—
Cedar	1.4	10.2 – 30.5
Total	100.0	

Results and Discussion

Snow depths on the study cutovers during 1975 reached 61.0 cm by 21 January and remained at that approximate depth until the end of February. On 10 January, a 2.5-cm rainfall resulted in a substantial crust at the 46.0-cm level of the snow cover. The crust was composed of 0.6 cm of ice lying between two 1.9-cm layers of less dense ice crystals.

Complete sets of data were collected on 48 of the 73 moose beds encountered. Approximately 81.0% of the moose bed sites were associated with immature coniferous clumps averaging from 2.5 to 7.6 cm in diameter at breast height (Table 1) when the mean snow depth at bedding sites was 67.3 cm (Table 2). Des Meules (1965) found that when snow depths ranged from 61 to 76 cm, 64.0% of the moose beds were found in association with immature coniferous clumps of less than 10.2 cm in diameter at breast height. He also noted that with snow depths of approximately 66 cm at bed sites, the mean distance from the center of the bed to the nearest "large" coniferous stem was 1.5 m. In this study, with identical snow depths, the most effective potential

TABLE 2—Snow gradients in the vicinity of 48 moose beds recorded 13 January – 28 February 1975 on the Spruce River Road cutovers

Date (1975)	No. beds in sample	Mean depth of snow 3.1 m in direction of least cover, in cm	Mean depth at bed site, in cm	Mean depth of snow 3.1 m in direction of best cover, in cm	Difference in mean snow depths over 6.2 m in vicinity of bed, in cm
13 Jan.	1	61.0	63.5	52.3	8.6
25 Jan.	7	76.4	64.0	65.0	11.4
31 Jan.	3	77.0	66.3	62.2	14.7
4, 5 Feb.	16	68.6	68.1	48.0	20.6
12 Feb.	18	76.4	72.6	64.3	12.2
28 Feb.	3	73.7	69.3	70.1	3.6
Total	48				
Means		72.2	67.3	60.3	

TABLE 3—Mean distances to the most effective windbreaking coniferous cover from the edge of moose beds in the Spruce River Road cutovers, 13 January – 28 February 1975

Date	No. beds sampled	Average distance to the most effective cover, in m
13 Jan.	7	2.5
20 Jan.	11	0.8
25 Jan.	7	1.2
31 Jan.	11	1.6
4, 5 Feb.	13	1.4
12 Feb.	18	1.0
28 Feb.	3	2.1
Total	70	
Mean		1.5

windbreaking immature coniferous cover was an average of 1.5 m away from the edge of beds (Table 3).

No direct data were collected to determine whether immature coniferous clumps were being used by moose as windscreens. In about 60% of the cases, however, the most effective cover was found either N, NE, NW, or W of the moose bed sites (Table 4). Weather records from the meteorological office in Thunder Bay reveal that prevailing winds were from these same directions approximately 63% of the days from 13 January to 28 February 1975, the period when bedding data were collected.

Table 2 data illustrate the usual relationship involving potential windbreaking cover, depth of snow at bed site, and depth of snow 3.1 m in the direction of the most effective coniferous cover for the moose beds in this study. Moen (1973) studied the movement of air in the lee of a windbreak, and his findings suggest that turbulence develops in the lee of a windbreak. One main result is that air movement, instead of being directed horizontally, is directed downwards, sometimes perpendicular to the ground. Snowflakes following this pattern of air movement would tend to build up much more quickly in the area of the bed site and behind it than immediately adjacent to the windbreak where air movement is calm. It would seem likely that the significant ($P < 0.05$, Duncan's multiple range test) snow-depth differences in the area of the conifer cover where moose bedded was created in a similar manner. For this to occur, the prevailing winds would have to be from the conifer cover towards the bed site, indicating that moose were bedding in the lee of conifer cover for protection from prevailing winds. Since there is no wind crust, the softer, more compressible snow may also provide a more attractive bedding medium for moose (Des Meules 1965). The snow gradient in the lee of coniferous cover also allows the moose a choice of snow depths in which to bed.

The data suggests that moose bed in a manner that allows them to utilize radiant energy from the sun. Least effective coniferous cover was recorded in the direction of S, SE, or SW in 59% of the cases at bed sites (Table 5). Moose bedded at these sites could receive sunlight unobstructed by coniferous cover. The dark coat of the moose would absorb much of the solar radiation available. Moen (1973) pointed out that this solar radiation could reduce the thermal gradients in an animal's hair layer, thus reducing heat

TABLE 4—Directions from which moose received the best windbreaking protection while bedded, 13 January – 28 February 1975

	Direction of most effective cover				
	Northerly directions	E	W	Southerly directions	Total
Frequency of occurrence, %	45.1	22.6	15.2	17.0	99.9%

TABLE 5—Directions from which moose received the least windbreaking protection while bedded, 13 January – 28 February 1975

	Direction in which least effective cover lay				
	Northerly directions	E	W	Southerly directions	Total
Frequency of occurrence, %	13.8	11.1	16.2	59.0	100.1%

loss through conduction.

In summary, it appears that residual coniferous cover may be an important component of the moose's winter range in northern Ontario mixed upland cutovers, as it provides thermal advantages to the animal when bedding. This in turn would lower the species' energy requirements and perhaps have survival value during severe winters.

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Spring and Summer Food Habits of an Ermine (*Mustela erminea*) in the Central Arctic

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Few quantitative data are available on the diet of the Ermine (*Mustela erminea*) in North America. The only studies of which I am aware are those of Hamilton (1933), Aldous and Manweiler (1942), Maher (1967), and Fitzgerald (1977). The following data are therefore of interest.

While conducting a preliminary ecological investigation of lemmings on the island of Igloolik (69°24′N, 81°49′W), off the Melville Peninsula, I discovered, on 9 August 1977, the active den site of an Ermine. After a thorough inspection of the site, 102 scats and 13 portions of lemming bodies were obtained for analysis. Prey items were identified on the basis of hairs and feathers found in the scats and on dental and skeletal remains from scats and body parts. No attempt was made to identify bird remains to species and each scat was presumed to represent one individual prey item, unless it could be proven otherwise.

The den site, measuring approximately 20 by 45 m, was located on a small ridge near the top of a 450-m, gently inclined, east-facing slope. It was quite rocky with numerous small limestone cavities. Vegetation on the site was sparse, consisting mainly of Mountain Avens (*Dryas integrifolia*) and lichen patches, with some mosses. Surrounding the den area was an extensive expanse of poorly-to-moderately developed *Dryas-Salix* and *Dryas*-lichen heath, intermixed with bare stretches of limestone and gravel. The nearest wet meadows of *Carex stans* and *Eriophorum angustifolium* were, with the exception of a small patch near to the den measuring roughly 60 by 100 m, some 450 m removed from the den site.

Analysis of the fecal material and body parts yielded the following numbers of individual prey items: Collared Lemmings (*Dicrostonyx torquatus*), 106; Brown Lemmings (*Lemmus sibiricus*), 9; birds, 26; and insects, 1. In addition to these items, some plant material was found. But as this material occurred in such small amounts and only in some scats, and as none of it appeared to have been digested, I suspect that it had been ingested unintentionally. In many cases the bone fragments of lemmings were poorly ossified, indicating that juveniles constituted a substantial portion of the diet. Considering the availability of nestlings in the area, many of the birds taken by this weasel may also have been young. The most common small birds in the area were Lapland Longspurs (*Calcarius lapponicus*), Snow Buntings (*Plectrophenax nivalis*), Baird's

Sandpipers (*Calidris bairdii*), White-rumped Sandpipers (*C. fuscicollis*), and the somewhat larger Golden Plover (*Pluvialis dominica*).

The den was located in an area of rocky heath, so I expected that Collared Lemmings would predominate in the diet. This species reportedly prefers such habitats, at least in summer, whereas the Brown Lemming restricts its movements largely to wet meadows and adjacent areas (Banfield 1974). Despite these spatial arrangements, the preponderance of Collared Lemmings taken by this Ermine was surprising since Collared Lemmings appeared to be at a population low; I did not observe any free-ranging individuals during my 28 days on Igloolik. Brown Lemmings, although seemingly more numerous than the above, also appeared to be at moderately low densities; only 13 free-ranging individuals were sighted. My studies in southern Ontario (unpublished) have shown that Ermine are capable of regularly traversing distances greater than 500 m. Brown Lemmings from the wet meadows described above were therefore potentially accessible to this Ermine. The foregoing observations on lemmings were substantiated by live-trapping. Twelve hundred trap-days, checked twice daily, yielded only four captures of two Collared Lemmings and 30 captures of 14 Brown Lemmings. Approximately 70% of the trapping effort was in habitats considered favorable to Collared Lemmings. Custom-made wooden live-traps were used to trap lemmings. According to local observers, lemming populations on Igloolik have been relatively low since the high of 1970. The scarcity of Snowy Owls (*Nyctea scandiaca*) this year (1977) further indicated relatively low lemming populations. Only one owl was sighted during the entire summer. More were seen the previous year (M. C. Lewis, personal communication). The only other lemming predator noted on the island was the Long-tailed Jaeger (*Stercorarius longicaudus*).

For comparison, 30 Snowy Owl pellets of undetermined age, from a variety of locations on the island, were collected and examined. These contained the following numbers of prey items: Collared Lemmings, 89; Brown Lemmings, 12; birds, 4. Both predators must, by necessity, exploit much the same food sources as little else is available. Direct comparisons in this case, however, are not valid as the owl pellets were from previous years and only one individual Ermine was involved. It is quite probable that Ermine living in or near wet meadows exploit Brown Lemmings to a much greater extent than did the individual discussed here.

The presence of the Ermine whose food habits are described herein, and one other individual observed approximately 5 km from the described den site, shows that Ermine are able to persist in areas where lemming densities are relatively low.

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Red Squirrels, *Tamiasciurus hudsonicus*, in the Salmonier River Valley, Newfoundland

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Goudie, R. Ian. 1978. Red Squirrels, *Tamiasciurus hudsonicus*, in the Salmonier River valley, Newfoundland. Canadian Field-Naturalist 92(2): 193-194.

Introduced Red Squirrels (*Tamiasciurus hudsonicus*) have become established in three isolated parts of insular Newfoundland. The first two introductions, on the Great Northern Peninsula and on Camel Island, Notre Dame Bay, and the establishment of populations resulting from them have been described by Northcott (1974) and Payne (1976). This note reports the third introduction.

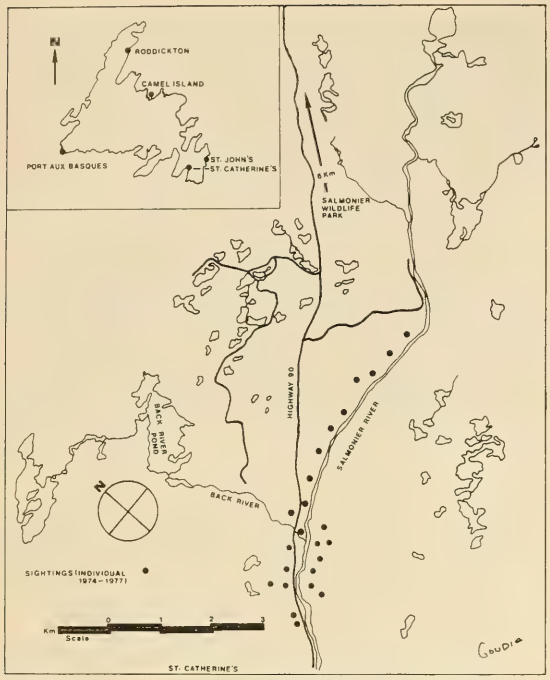

FIGURE 1. Red Squirrel observations in Salmonier River valley, Newfoundland. Insert top left: study area near St. Catherine's on insular Newfoundland.

Staff of the Newfoundland Wildlife Division, Department of Tourism, released four male and seven female Red Squirrels, captured from the Northern Peninsula population, at the Salmonier Wildlife Park (47° 16'N, 53° 17'W) on the Avalon Peninsula in July 1974 (Minty, personal communication).

There were three sightings by me and infrequent ones by other local residents during the fall and winter of 1974. These were mostly restricted to sheltered valleys in the area of the confluence of the Back River and the Salmonier River (locally known as the Back River Hills, 13 km southwest of the introduction site (Figure 1). Observations in the Salmonier River valley during the fall of 1975 indicated the presence of the squirrels; however, the population density did not appear to have increased substantially during 1975 (I recorded six sightings from 16 10-km transects along Salmonier River valley). The Red Squirrel sightings increased dramatically during the fall and winter within the river valley basin. The recording of 14 sightings from the same transects during the winter of 1976–77 indicated a population of no fewer than 200 individuals, centered in the area of the confluence of the Back River and Salmonier River. These observations indicate the population is spreading, at least within the confines of the boreal forest cover. Present sighting data indicate the population has a distribution of some 50 km^2 with sightings up to 15 km southwest of the release site.

The general area of confluence of the Back River and the Salmonier River is very rich in forest growth with north-facing slopes dominated by Balsam Fir (*Abies balsamea*) = Yellow Birch (*Betula lutea*) forests with a dense ground cover of ferns (*Dryopteris spinulosa*), scattered mosses, and herbs. South-facing slopes lack the high proportion of hardwood species prominent in the aforementioned cover and are covered by Balsam Fir forests with a dominant moss ground cover of *Hylocomium splendens, Pleurozium schreberi,* and *Rhytidiadelphus loreus*. Both slopes in this lower section of the Salmonier River valley support rich forest cover in differing stages of succession. The productivity of this general area may account for the concentration of the Red Squirrel population in this vicinity.

I predict that Red Squirrels will extend their range radially within the boreal forest of the Avalon Peninsula. Forests like that of Salmonier River valley are abundant on well drained slopes, terraces, and hummocks within the Boreal Forest Ecoregion (Meades 1973). Sections of forest are interspersed with extensive areas of raised bog and slope bog formation (Wells 1976). I doubt that these bogs will be a barrier to squirrel dispersal.

The present relatively low number of mammalian predators such as Red Foxes (*Vulpes vulpes*), Lynx (*Felis lynx*), and Mink (*Mustela vison*) within the Salmonier River valley may have favored a rapid increase in Red Squirrel density. Red Squirrels are a welcome addition to the island's fauna since small mammal prey species are limited to Meadow Voles (*Microtus pennsylvanicus*) and Masked Shrews (*Sorex cinereus*). The endangered Newfoundland subspecies of Marten (*Martes americana atrata*) may eventually utilize Red Squirrels as its major prey species as is the case on the adjacent mainland. The result of the overall introduction of Red Squirrels to Newfoundland may help catalyze the expansion of Martens there.

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Flycatching by Male Song Sparrows, *Melospiza melodia*

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Tompa (1963) observed that Song Sparrows on Mandarte Island, British Columbia, occasionally flew high into the air to capture insects, much like typical tyrannid or muscicapid flycatchers. During the 1975 breeding season on Mandarte Island, British Columbia, I noticed that male Song Sparrows seemed to flycatch more than females. By 1976 and 1977, I had marked all resident breeding Song Sparrows and was therefore able to watch known individuals to see whether males really attacked flying insects more often.

Between 7 April and 2 July 1976 and 31 March and 2 June 1977, I collected records of flycatching by Song Sparrows of known sex during regular census walks and during nest watches. I spent equal time observing males and females during nest watches, when both were feeding nestlings, but encountered males slightly more often during census walks because of their more frequent presence on high perches.

I observed flycatching most often on calm warm days in April. A sparrow typically flew from a perch on top of a 1- to 3-m-high shrub and rose up to 10 m in the air. Several lunges, accompanied by snapping of the beak, were often made at the prey, which was often an asilid fly. The reason that most flycatching was observed in April may be that this was the peak activity time for asilids. Another possible explanation is that Song Sparrows are less inclined to leave their territories to forage in undefended parts of the island at this time. Tompa (1963) in fact found that Song Sparrows fed outside their territories less often in April than in any month during the non-breeding season, but he did not collect information during May, June, or July. Although an accurate record of successful sallies was not made, most flycatching attempts seemed to be successful. In 1976, males accounted for 88% of the individuals flycatching and 96% of the attempts at flycatching; in 1977, the corresponding percentages were 75% and 79% (Table 1). Although flycatching by females was clearly more common in 1977 than 1976, there were many more flycatching attempts by males than females within each year. I cannot explain why females were observed flycatching more often in 1977 than 1976.

How can the sexual differences in flycatching frequency be explained? One possibility is that male Song Sparrows, which have longer wings than females (Knapton 1973), are more efficient in flycatching. Wing loading (Greenewalt 1975) is an index of energy use during forward flight; the lower the wing loading, the more manoeuvrable the bird. Specialized flycatchers have very low wing loadings (Greenewalt 1975). I measured the wing areas and weights of 11 male and 8 female Song Sparrows during August 1977 and calculated the mean wing loadings for each sex. Male wing loading (0.35 g/cm^2) did not differ significantly ($P \geqslant 0.10$, t-test, df = 17) from that of females (0.38 g/cm^2). Males and females thus seem similar in the morphological trait most likely to influence flycatching.

I believe that a behavioral difference between the sexes during the breeding season is a more important cause of the sex difference in flycatching. Male Song Sparrows spend much of their time on high perches within their territory, either singing or looking for intruders (Nice 1943). In contrast, females seldom use

TABLE 1—Population sizes, numbers of individuals flycatching, and frequency of flycatching attempts by male and female Song Sparrows on Mandarte Island, British Columbia, in the springs of 1976 and 1977

Sex	Year	Minimum number of birds present	Number of individuals seen flycatching	Number of instances of flycatching
Males	1976	42	29	89
	1977	49	33	181
Females	1976	30	4	4
	1977	45	11	49

high perches, often move about inside shrub thickets, and spend much time incubating. I suggest that this difference causes males to see potential flying insect prey more often than do females, and enables them to launch aerial attacks from a high perch with less energy expenditure. Many of the female flycatching flights observed in 1977 were carried out from low perches and involved only very short flights.

Jon S. Greenlaw (personal communication) has noted a similar sex difference in flycatching frequency by Rufous-sided Towhees (*Pipilo erythrophthalmus*) in northeastern USA. Hence sex differences in foraging may be an incidental consequence of spatial separation of male and female activities, and not an evolved mechanism to avoid intersexual competition.

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Feeding at a Trap-net by Black-crowned Night Herons

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Middleton, A.L.A. 1978. Feeding at a trap-net by Black-crowned Night Herons. Canadian Field-Naturalist 92(2): 196.

At dusk on 10 July 1971, at Sarnia, Ontario five Black-crowned Night Herons (*Nycticorax nycticorax*) flew in a northeasterly direction from the trees behind me out over the calm surface of Lake Huron. I followed their flight with binoculars and was surprised to see them descend towards a well-marked (flagged buoys) commercial trap-net, located approximately 300 m offshore in 7 m of water. As the birds' bodies remained clear of the water, they must have landed on the net or on the leads running from shore. The five birds were dispersed around the net and its leads, and each seemed to be engaged in catching prey. Unfortunately the light was too dim to determine whether any prey was captured.

I repeated my observations on the following evening, when weather conditions were similar. At dusk five herons again flew from the trees to the net and apparently began fishing. Once more I was unable to identify the prey or to determine the capture rate. No further observations were made.

Generally herons are accepted to be shallow-water feeders. Recent reports, however, indicate that both Black-crowned Night Herons (Crawford, R.D. 1976. Iowa Bird Life 46: 20–21) and Great Blue Herons (*Ardea herodias*) (Godin, J.J. 1977. Canadian Field-Naturalist 91: 88–90) will resort to open-water feeding under certain circumstances. Although I could not establish the identity of the prey, several species of small fishes would have been available to the herons (H.R. MacCrimmon, personal communication). Additionally, the fact that the herons flew directly to the net on two successive evenings suggests that they knew its location and must have had some previous success in capturing prey at the net. Finally, the birds were not swimming but were apparently standing on the mesh of the net or the lead lines, from which they could dart at fish either trapped in the net or swimming close to the surface.

As suggested by Crawford (*op. cit.*), open-water feeding by Black-crowned Night Herons may be a more commonly used feeding behavior than has been previously recognized.

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Occurrence of *Carex careyana* in Canada

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Ball, Peter W. 1978. Occurrence of *Carex careyana* in Canada. Canadian Field-Naturalist 92(2): 197-198.

Carex careyana is a rare sedge in Canada. It was first recorded by Klugh (1906) from Guelph, Ontario. MacKenzie (1935) and Soper (1949) also mentioned the occurrence of this species in Ontario, but both of these records seem to have been based on the specimens collected by Klugh. The species has also been recorded from one locality in southern Quebec (near Sweetsburg) cf., Raymond 1941), but no confirmatory specimens have been seen, and Rouleau (1946) throws some doubt on its occurrence in that province. Boivin (1967) excluded *C. careyana* from the Canadian flora, but in a personal communication (1976), he stated that he has subsequently traced material collected by Klugh in 1905 and 1906 in the herbaria of Queen's University, Kingston (QK) and the University of Guelph (OAC). None of these specimens give any precise details of the locality, other than Guelph, but a previously untraced specimen in the herbarium of the National Museum of Canada (CAN) gives the location as Dairy Bush, Ontario College of Agriculture, Guelph.

In addition to the locality discovered by Klugh the species has previously been collected from two other localities in southern Ontario. Curiously enough, both collections were made by A. A. Wood in Middlesex County in 1934. One, correctly determined as *C. careyana,* was from Strathroy, the other from Poplar Hill about 10 km east of Strathroy. This second specimen was originally determined as *C. platyphylla,* but this determination was corrected by Boivin in 1974. Both specimens are preserved in the herbarium of the Biosystematics Research Institute, Ottawa (DAO).

This investigation was prompted by the discovery of a fourth locality for this species in Ontario. This locality, in Halton County, about 3 km south of Rockwood is only about 12 km from Klugh's original locality. The known distribution of *C. careyana* in Canada is shown in Figure 1. The clustering of the locations into two centers about 150 km apart, and each 150 km or more from any locality in the United States is a conspicuous feature of the map. This map should be compared with that given by Voss (1972) for this species in Michigan. Although the species is not common in Michigan it is found in about half of the counties in the southern half of the state. This suggests that the species, although rare in Ontario, is probably much more widespread in the province but has been overlooked. This explanation is supported by the manner in which the new locality was discovered. It was first collected there in 1966 by B.W. Davies, who at the time was a graduate student working under the supervision of P.F. Maycock (Maycock, Stand 1114). Owing to the lateness of the season, the species could not be identified in the field, so a specimen was collected and subsequently tentatively determined as *C. laxiculmis,* another member of the section LAXIFLORAE. Whilst checking material of section LAXIFLORAE the anomalous characters of this specimen were noted and eventually a single perigynium was found on the withered culm, which led to a tentative re-determination as *C. careyana* by A.A. Reznicek and the author. This was confirmed in 1974 when the locality was rediscovered and good material of the species was collected.

FIGURE 1. The distribution of *Carex careyana* in Ontario.

Carex careyana is a sedge that is relatively easy to recognize. Although a member of the section LAXIFLORAE which, as a whole, can be difficult to distinguish from several other sections, *C. careyana* is a member of a small group within the section which has very broad evergreen rosette leaves, and culm leaves with very reduced blades. Besides *C. careyana,* the other species in the group in Canada are *C. plantaginea* and *C. platyphylla. Carex platyphylla* can be recognized throughout the year by the glaucous or gray-green rosette leaves which are completely lacking in red or purple color. *Carex plantaginea* and *C. careyana* have bright green basal leaves which have strong reddish-purple color at the base. Unfortunately, it does not seem possible to distinguish reliably between these two species in the vegetative state. *Carex careyana* has the basal leaves 8–17 mm wide, whilst *C. plantaginea* has the basal leaves 12–30 mm wide, these being proportionally much broader. From about the middle of May to the end of June, when fruiting culms are present on these species, they can be readily separated. *Carex careyana* has short green blades on the culm leaves which also have purple sheaths, and the perigynia are 5–6.5 mm long. *Carex plantaginea* has culm leaves which are completely purple and almost completely devoid of a blade, whilst the perigynia are only 3–4.5 mm long. *Carex platyphylla,* besides lacking all purple color, has the perigynia only 3–4.5 mm long. Other species which might be confused with *C. careyana* are *C. albursina, C. laxiflora, C. laxiculmis* and other members of the section LAXIFLORAE that sometimes have broad basal leaves. All of these species, however, have little or no purple coloration, have well-developed blades on the culm leaves, and have the perigynia less than 5 mm long. Species in several other sections have dark purple color on the basal leaves but in all cases the blades are much narrower than those of *C. careyana.*

Ecologically the three species of this group are very similar. The Halton County location for *C. careyana* is a small area dominated by large individuals of *Acer saccharum* (Sugar Maple). The stand is near the top of a slope with a northern aspect. It has a fairly rich ground flora with *Phlox divaricata, Allium tricoccum, Schizachne purpurascens,* and nine other species of *Carex* all prominent at the time that *C. careyana* is in fruit. *Carex careyana* does not occur throughout the stand, but is found on the crest of a ravine at the northern edge. The sides of the ravine are covered by a stand of *Thuja occidentalis* (White Cedar), *Abies balsamea* (Balsam Fir), *Picea glauca* (White Spruce), and *Betula papyrifera* (Paper Birch). It is not unusual to find *C. platyphylla* in similar situations.

The available evidence suggests that *C. careyana* should be looked for throughout southern Ontario and the extreme southern part of Quebec. It is confined to hardwood forests that have a comparatively rich ground flora, but it seems to occur both on rocky limestone and on sandy substrates.

Specimens Examined

Halton County: 1½ m. (2.5 km) west of Crewsons Corners on Highway 7, then 1 mi (1.7 km) south, Stand 1114, 28 June 1966, B.W. Davies (Herb. P.F. Maycock!). About 2 mi (3.3 km) south of Rockwood, 20 June 1974, P.W. Ball 10374 (TRTE!).

Wellington County: Guelph, 28 May 1905, 8 June 1905, 1 May 1906, 4 May 1906, A.B. Klugh (QK, Photo DAO!). Guelph, 28 June 1905, A.B. Klugh (OAC, Photo DAO!). Dairy Bush, OAC Guelph, 30 April 1906, A.B. Klugh (CAN!).

Middlesex County: Poplar Hill, rich sandy woods and banks, 14 May 1934. A.A. Wood (DAO!) (sub *C. platyphylla*). Strathroy, Conley's Wood, 29 May 1934, A.A. Wood (DAO!).

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Addendum

A further locality for *C. careyana* in Halton county has recently been detected. It is about 12 km south of the new locality reported above.

Halton County. Halton Forest, Currie Tract, near Campbellville, 14 May 1977. P. Catling (TRT!) (sub *C. laxiflora).*

30 March 1978

Wheatears and a Magnolia Warbler in Southern Davis Strait

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Tingley, Stuart I. 1978. Wheatears and a Mangolia Warbler in southern Davis Strait. Canadian Field-Naturalist 92(2): 199.

While conducting biological investigations aboard a seismic vessel (*RV Kirsten Bravo*) in the Cumberland Sound region of Davis Strait in late August and September 1976, I recorded migrant passerines seen near to, or landing on, the ship. Two records are of special interest.

Between 2400, 31 August and 0430 GMT, 1 September, I recorded a total of seven or eight Wheatears (*Oenanthe oenanthe*) circling the ship in the cold rain which had fallen throughout the day. Several of the birds landed on the ship for periods ranging from a few seconds to a half hour. Many birds appeared quite exhausted and I was able to capture and photograph one individual (photo on file at National Museum of Natural Sciences). I also photographed a second similar individual perched on a railing. Wing measurement of the captured bird was 101.5 mm., confirming its subspecific identity as *O. oenanthe leucorhoa,* the breeding form of eastern Canadian Arctic and sub-arctic regions as well as Greenland (Stejneger 1901). Although light conditions were poor, it appeared that two birds had well-defined ear patches indicative of adult males, the rest of the birds probably being adult females or immatures. The ship's position during the period of observation was roughly 60° 10′N, 59° 15′W.

These birds probably originated in the eastern Canadian arctic and sub-arctic regions as well as grounds in the Old World via Greenland. Wheatears from the northern part of their Canadian range apparently use Greenland as a stopping-off place in their fall migration while those in the southern part of their range may make a direct non-stop flight across the Atlantic (Salomonsen 1951; Todd 1963). Snow (1953) reports two fall sightings of Wheatears from ships in southeastern Davis Strait which were also probably Canadian birds. The date of my observation falls within normal migration dates for Canadian Wheatears as recorded by Snyder (1957), though Wynne-Edwards (1952) did not record this species in central and southeastern Baffin Island after 11 August during his study of that area in 1950.

Around 1500 GMT, 15 September, I discovered an immature Magnolia Warbler (*Dendroica magnolia*) flying about the cable room on the lower deck. The bird was extremely wary and flew about the room searching frantically for an escape route, which led me to believe that the bird had only recently arrived. The ship's position at the time of, and for 12 h before the observation was 62° 55′N, 60° 23′W. Godfrey (1966) reports Magnolia Warbler possibly breeding as far north as Hamilton Inlet, Labrador, but does not mention any records from the eastern Canadian Arctic. Surprisingly, Salomonsen (1967) reports two records of this warbler for Greenland, one in Godthab District sometime in 1875, and a second in Sukkertoppen District on 1 October 1950.

Other migrant passerines recorded on the cruise in mid-southern Davis Strait were Water Pipit (*Anthus spinoletta*), Hoary Redpoll (*Carduelis hornemanni*), Common Redpoll (*Carduelis flammea*), Lapland Longspur (*Calcarius lapponicus*), and Snow Bunting (*Plectrophenax nivalis*).

These observations were made during environmental investigations sponsored jointly by Imperial Oil Ltd. and the Canadian Wildlife Service. Special thanks to D.N. Nettleship for critically reading the manuscript and making many helpful suggestions.

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Records of the European Skipper in Newfoundland

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Jackson, Bernard S. 1978. Records of the European Skipper in Newfoundland. Canadian Field-Naturalist 92(2): 200.

The European Skipper, *Thymelious lineola* (Lepidoptera: Hesperiidae), was introduced to North America in or before 1910 in the region of London, Ontario (Alexander B. Klots. 1951. A field guide to the butterflies of North America, east of the Great Plains. Houghton Mifflin Company, Boston). It has not been previously reported from Newfoundland.

The insect collection at the Agricultural Research Station, St. John's, contains a specimen taken on 24 July 1975 from the radiator grill of a vehicle that had recently arrived in St. John's, from mainland Canada (R. F. Morris, personal communication). This specimen was probably hit before the vehicle entered Newfoundland. The following are my reports of observations of the species in Newfoundland.

At 1530 hours on 3 August 1976 a European Skipper was observed feeding from the flowers of Fireweed (*Epilobium angustifolium*), against the carpark in the Oxen Pond Botanic Park, St. John's, Newfoundland (47°34′N, 52°43′W). A subsequent check of nearby grassy areas revealed a total of 11 freshly emerged individuals. Specimens were seen intermittently over the following 2 weeks and a pair was collected for the insect collections at the Agricultural Research Station, St. John's. The last sighting for the year was of three individuals on 19 August 1976.

It is possible that these individuals originated from eggs laid in the general area the previous year, but the origin of the gravid female(s) is (are) unknown. No plants with a known or suspected capability as a host for the larvae of this skipper were brought into the park from outside sources within the previous 2 years. An entomologist spent the greater part of the 1975 season collecting in the area without finding a single specimen of this species; this would suggest that very few were present at that time.

Independent searches, by myself and R. F. Morris, of adjacent rough meadows and grassy roadsides, up to a distance of 100 m from the original discovery site during the period the skippers were observed, failed to reveal any further specimens.

Nevertheless during late July and early August 1977 European Skippers were again sighted and were common around the discovery site. On occasion it was possible to view 12 on the wing simultaneously.

On 26 July 1977, R. F. Morris (personal communication) discovered European Skippers at a site approximately 10 km north of Bishops Falls, Newfoundland (49°01′N, 55°30′W). Three specimens were collected for the insect collections at the Agricultural Research Station, St. John's.

The populations observed at both sites probably originated from the drift movement of adult insects entering the area from mainland Canada.

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First Record of the Ancient Murrelet for Alberta[1]

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Weseloh, D. Vaughn and Linda McKeane Weseloh. 1978. First record of the Ancient Murrelet for Alberta. Canadian Field-Naturalist 92(2): 200-201.

On 25 October 1975 at 1435 hours, we observed and later captured a winter-plumaged Ancient Murrelet, *Synthliboramphus antiquum*. The bird was sighted just east of Edmonton in the North Saskatchewan River. We observed the bird, which appeared to be very weak, for 5–10 min, during which

[1]Provincial Museum of Alberta Natural History Contribution Number 41.

time it drifted with the current for about 50 m, then dragged itself onto shore. After watching the seemingly exhausted bird for another 2–3 min, we captured it with only minimal effort and photographed it.

On our return to Edmonton, we showed the bird to Bob Lister, Eric Tull, Steve Johnson, John Richardson, Terry Thormin, Gary Searing, and Larry Patterson. By 1930 hours, the bird appeared much weaker and it had died by 2000 hours. It is now preserved as specimen #Z75.92.1 in the Provincial Museum of Alberta.

Inland appearances of the Ancient Murrelet are not exceptional. E. A. Munger (1965. Inland wanderings of the Ancient Murrelet. Wilson Bulletin 77: 235–242) and N. A. M. Verbeek (1966. Wanderings of the Ancient Murrelet: some additional comments. Condor 68: 510–511) have discussed the phenomenon at length and show that inland sightings of this species usually occur during late October and November with a secondary peak in March. These periods of inland occurrence correspond to the autumn and spring migration periods, respectively, of this North Pacific alcid. Both those authors report that autumn records are often coupled with onshore winds and poor visibility during Pacific storms. They speculate that the route of travel from the coast of inland-occurring birds is probably southeasterly, representing gradual displacement, rather than due west to east.

For a full week prior to the Edmonton murrelet sighting, weather maps for the British Columbia coast showed strong westerly winds and snow showers, circumstances ideal for an easterly displacement of Ancient Murrelets migrating southward. The duration of these weather factors coupled with the physical condition of the bird when found, lead us to believe that this individual may have been in the North Saskatchewan River, or at least inland, for some time and/or distance. The bird, a male, weighed 122 g (after freezing), whereas normal weight for Ancient Murrelets is 200–210 g (Spencer Sealy, personal communication).

This is the first record of the Ancient Murrelet, or any member of the family Alcidae, for Alberta.

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House Sparrows Nesting near a Swainson's Hawk Nest

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McGillivray, W. Bruce. 1978. House Sparrows nesting near a Swainson's Hawk nest. Canadian Field-Naturalist 92(2): 201-202.

Scattered reports describe close nest associations of passerines and raptors (Robson 1955; Rotschild 1959; Brown and Amadon 1968; Garber 1972). Bent (1937) noted that small birds, typically the Western Kingbird (*Tyrannus verticalis*) and Northern Oriole (*Icterus galbula*), will occasionally nest near a Swainson's Hawk (*Buteo swainsoni*) nest. Normally the cohabitant builds in the same tree; however, it will periodically incorporate its nest into that of the hawk.

While studying House Sparrow (*Passer domesticus*) demography, I found three sparrow nests within 3 m of an active Swainson's Hawk nest. The site was discovered 5 August 1977 in the vicinity of Conrich, Alberta, 5 km east of Calgary, and observed until 10 August. The raptor nest was 8 m high in a dead balsam popular (*Populus balsamifera*). One sparrow nest was built into the bottom of the *B. swainsoni* nest, another 2 m away was in the same tree, and the third was at the same level, 3 m distant in an adjacent tree. The hawk's nest contained two juveniles, aged 20–25 days, that occasionally leaned over the edge to observe the movements of the nest beneath theirs. All three sparrow nests were active; two held nestlings and the other was being repaired. In each case the adults were regularly visiting these nests. The landowner informed me that a pair of Swainson's Hawks used the same location in 1976, confirming the existence of a nest structure throughout the period of sparrow nest-site selection.

Brown and Amadon (1968) consider doubtful the possibility that benefit accrues to weaverbirds of the genera *Malimbus* and *Ploceus* that nest near raptors. This places my observations in an interesting context. First, tree-nesting House Sparrows throughout the study area almost exclusively utilized coniferous trees. The sparrow nest in the bottom of the hawk nest was

protected from adverse weather, but the other two were exposed and vulnerable. Secondly, no other House Sparrow nests were found in the woodlot surrounding the nest tree, the nearest being 200 m distant in a farm structure. The restricted distribution and atypical situation of *Passer* nests implies association by choice. In addition, a lowering of reproductive output as a consequence of nest exposure (Murphy 1977) would be offset if nestling losses and adult mortality from predators were reduced. The diet of the Swainson's Hawk consists of small rodents, insects, and only infrequently birds (Bent 1937; Godfrey 1966). House Sparrows in the area were observed to suffer nestling mortality from Black-billed Magpies (*Pica pica*); and probably Common Grackles (*Quiscalus quiscula*). These birds and small raptors may be excluded from the immediate nest area by adult Swainson's Hawks. This protection could account for the attractiveness of otherwise structurally inadequate nest sites.

Support for this research was given by NSF grant BMS-76-02225. Helpful discussions were held with Richard F. Johnston, Peter E. Lowther, and John T. Paul, Jr.

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News and Comment

Editor's Report for 1977

We are particularly pleased with the reliable and pleasant service we have received from our printer. The issues of *The Canadian Field-Naturalist* printed by M.O.M. Printing in Ottawa certainly represent good products.

The cost of putting a manuscript into print is considerable despite the fact that those of us who edit and produce *The Canadian Field-Naturalist* on an essentially volunteer basis receive mainly personal satisfaction. Expenses for the operation are covered through page charges to authors (these contributions by no means cover the total cost), subscriptions to *The Canadian Field-Naturalist*, an allotment (40% in 1977) of the fees paid by members of The Ottawa Field-Naturalists' Club, and a grant from the National Research Council of Canada. Because several authors who had research grant or institutional funds available have paid page charges for all published pages, not just the obligatory page charges for pages in excess of six, our finances are in good shape. Nevertheless, in our proposed budget for 1977, we included a contingency fund of $2000 to act as a buffer for sudden, unanticipated cost increases but this had to be removed. Although the committee of the National Research Council of Canada that reviewed our application for a Scientific Publication Grant was sympathetic, it did not wish to contribute to a contigency fund in view of the severe competition amongst all applicants for the funds available. Therefore, the grant we received was considerably lower than that requested. For 1978 we are essentially operating on a zero-base budget.

In 1977 *The Canadian-Field-Naturalist* received 137 manuscripts for consideration. This number is slightly lower than the 147 received in 1976 and the peak of 167 in 1975. The four issues of *The Canadian Field-Naturalist* published for 1977 (Volume 91) contain 101 scientific papers originally submitted from 1974 to 1977. The breakdown according to subject matter is as follows: birds, 30; mammals, 31; plants, 16; fishes, 10; amphibians and reptiles, 8; invertebrates, 4; and others, 2.

Towards the end of the year Associate Editor for Ornithology A. J. Erskine agreed to take on the task of dealing directly with authors and referees for all the new submissions on birds. I anticipate that this will lighten considerably my rather heavy work load.

The April-June issue contained updated details on current editorial policy while in the July-September issue I commented on and stated the journal policy for the reporting of range extensions, this following the editorial on the subject by Associate Editor David P. Scott. Also noteworthy in the July-September issue was the announcement by Associate Editor George H. La Roi of our intention to publish in *The Canadian Field-Naturalist* a new series on "The Biological Flora of Canada." We hope that the problems involved in starting this new series will be worked out and that the series will be a welcome addition to the literature.

Although the high standards of our journal are to a certain extent dependent on the way it is edited and produced, they must also depend on submissions of high quality by authors and on authoritative and constructive reviews by referees. The communications of appreciation received during the year from readers and authors were welcome and personally gratifying to us.

LORRAINE C. SMITH
Editor

Kirkland's Warbler Protected in Ontario

Ontario recently added Kirkland's Warbler as the 13th species to be protected under Ontario's Endangered Species Act. A census of the central Michigan Jack Pine plains, the only known breeding range of the bird, had indicated that only about 450 birds survive. The bird has been seen in Ontario, including a sighting in the summer of 1977. Ontario, recognizing a need for cooperation with the Michigan-based Kirkland's Warbler survival project, has now given protection to the species.

1978 Council — The Ottawa Field-Naturalists' Club

At the Annual Business Meeting of The Ottawa Field-Naturalists' Club on 10 January 1978, the Members of Council proposed by the Nominating Committee (including one person nominated by the membership-at-large) were elected and are now in office. *New member of Council.

Members of Council

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Request for Participants — International Shorebird Surveys 1978

A cooperative International Shorebird Survey scheme has been organized by the Canadian Wildlife Service and the Manomet Bird Observatory since 1974 to obtain information on shorebird migration and to identify and document areas of major importance. This scheme has been highly successful, with much very valuable information on shorebird distribution and migration coming from contributors throughout eastern Canada and the USA, the Caribbean Islands and Central and South America. Information from the scheme will be valuable in assessing requirements for the future protection and conservation of the birds and their habitat. It is planned to make 1978 the fifth and final year of the project. Any observer who may be able to participate in regular counts of shorebirds during spring and autumn migration periods, as well as during the winter in shorebird wintering areas, is asked to contact one of the undersigned. Occasional counts from observers visiting shorebird areas on an irregular basis would also be most welcome. For areas in Canada: *Dr. R. I. G. Morrison, Canadian Wildlife Service, 2721 Highway 31, Ottawa, Ontario, Canada K1G 3Z7.* For areas in USA, Caribbean Islands, Central and South America: *Brian A. Harrington, Manomet Bird Observatory, Manomet, Massachusetts, USA 02345.*

Request for Information — Shorebird Color-marking

In 1978 the Canadian Wildlife Service will be continuing a large-scale program of banding and color-marking shorebirds in James Bay. During the past three years, over 30 000 shorebirds have been captured, resulting in more than 1200 'bird days' of sightings of dyed birds ranging from eastern Canada to South America. Much valuable information on migration routes and strategies is being obtained and observers are again asked to look out for and report any color-dyed *or* color-banded shorebirds that they may see. Reports should include details of species (with age if possible), place, date, color-marks and, if possible, notes on the numbers of other shorebirds present. For color-dyed birds, please record the color and area of the bird that was dyed. For color bands and standard metal leg bands, please record which leg the bands were on, whether they were above or below the "knee," the colors involved (yellow or light blue), and the relative position of the bands if more than one was on a leg (e.g., right lower leg, blue over metal, etc.). All reports will be acknowledged and should be sent to: *Dr. R. I. G. Morrison, Canadian Wildlife Service, 2721 Highway 31, Ottawa, Ontario, Canada K1G 3Z7.*

Levels for Air Contaminants Adopted

Maximum tolerable levels have been set for five major air contaminants under the Clean Air Act. The five contaminants — particulate matter, sulphur dioxide, carbon monoxide, oxidants (ozone), and nitrogen dioxide — are responsible for 90% of total air pollution in Canada.

Under the Clean Air Act of 1971, three levels for air quality were set — desirable, acceptable, and tolerable. Desirable is the level where the environment generally is not affected; acceptable is the level where minimal effects of contaminants are considered to be reasonable. When air quality conditions have deteriorated to the maximum tolerable level, prompt abatement action is necessary by local authorities. Surveillance of air quality in Canada over the past several years, however, has shown these levels are seldom reached.

Maximum tolerable levels for the five major contaminants were developed by a federal-provincial committee. The upper range of the five major air contaminants for tolerable levels is: particulate matter, 400 $\mu g/m^3$ (24-h average); sulphur dioxide, 800 $\mu g/m^3$ (24-h average); carbon monoxide, 20 mg/m^3 (8-h average); oxidants, 300 $\mu g/m^3$ (1-h average); nitrogen dioxide, 300 $\mu g/m^3$ (24-h average) and 100 $\mu g/m^3$ (1-h average).

Desirable and acceptable levels were adopted under the Clean Air Act in 1974 for four of the pollutants, and in 1975 for nitrogen dioxide.

These pollutants are produced in a number of ways. Particulate matter in solid or liquid form may originate with industrial processes as well as other human activities, and with nature. Particulates also reduce visibility and contribute to property damage and soiling. Sulphur dioxide results from industrial processes and the combustion of fossil fuels. Oxidants are produced in the atmosphere when reactive organic substances, chiefly hydrocarbons, are exposed to sunlight in the presence of nitrogen oxides. In addition to their possible connection with respiratory diseases, they also damage plants and materials such as rubber and textiles. Nitrogen oxides originate principally with high-temperature combustion processes. Carbon monoxide results from some industrial processes and from incomplete combustion of carbon-containing fuels. It decreases the oxygen-carrying capacity of the blood, and at excessive levels may impair mental processes.

National Air Quality Objectives are required to provide the following: a uniform yardstick to measure air quality in all parts of Canada; a basis for keeping the air clean in unpolluted parts of the country; a basis for determining priorities for tackling pollution problems; an indication of the extent of surveillance programs required; and a framework for enforcement programs by control agencies.

The newly-adopted Air Quality Objectives (Maximum Tolerable Levels) will be published in Part II of the Canada Gazette.

North American Conference on Common Loon Research and Management

A conference sponsored by the National Audubon Society and hosted by Syracuse University was held 12–14 August 1977 at the Minnowbrook Conference Center, Blue Mountain Lake, New York. Priorities determined by the participants included (1) establishment of an informal working group to serve as a clearinghouse for information on research and management efforts, (2) collection of historical loon nesting records for assessment of recent range contraction or expansion by this species, (3) coordination and standardization of breeding surveys and an effort to document the current breeding status of the loon, particularly in the northeastern USA, and (4) expanded research, including increased banding efforts and initiation of a winter banding program.

The working group, consisting of Judith W. McIntyre of Syracuse University, Richard L. Plunkett of the National Audubon Society, and Rawson L. Wood of the Loon Preservation Committee of the Audubon Society of New Hampshire, plans another meeting next year. Requests for conference summaries and other inquiries may be directed to the coordinator, *Judith W. McIntyre, Biology Department, Syracuse University, Syracuse, New York 13210.*

Book Reviews

Zoology

Wildlife Management in Europe

By Anne Innis Dagg. 1977. Otter Press, Waterloo. 324 pp. Paper $6.50 + .50 postage.

Readers of Dagg's 1974 book *Canadian Wildlife and Man* will find the present book familiar. The style is similar. The audience is basically the same. The message: "To study wildlife management in Europe is to glimpse problems of our own future." Dagg finds little evidence that North American biologists are keeping abreast of current wildlife management practices in Europe. This book is meant to remedy that. In the Preface Dagg writes, "This book was undertaken to bring together current research interests of Europe into one work, so that North American biologists can find out what European biologists are doing, and perhaps be stimulated by some of their ideas."

Dagg's point that North American biologists can learn much from their European counterparts is well taken. We can. Many of us do. Most of the Canadian research ecologists (wildlife and otherwise) with whom I am acquainted have regular contacts in Europe, primarily in Great Britain, Scandinavia, and the Soviet Union. Dagg must be more specific when she says there is little evidence that North Americans are current on European work. Her criticism is justified for some institutions and government agencies. The European experience is certainly not greatly reflected in North American wildlife legislation. But at the individual unofficial level a great many biologists (perhaps more so in Canada than in the USA) have been exchanging data for years.

The book may be divided arbitrarily into four sections. Section 1 deals with the main biotypes of Europe. Section 2 discusses species not adapting well to man-made changes. Section 3 is devoted to current European management practices of aquatic mammals, waterfowl, and non-game birds. Section 4 compares European game management laws and harvesting procedures with those in North America.

Dagg presents a general account of a wide range of management programs and practices from 26 European countries. Two hundred and forty-four animal species are mentioned in the book, and some comments on management practices or biology are given for approximately 75 of these. With such a large number, details are impossible. Dagg recognized this ("This work makes no attempt to be definitive, since it is based on research published only within the last decade. Its length precludes discussing any one species or country in depth . . ."). I feel, however, that she could have used a better judgment in selecting the pieces for inclusion. Availability of material should not have dictated volume. For example, the largest single section (9 pages) is on bird strikes, the hazards to aircraft from birds. This compares to 4 pages on moose. Much European and Soviet work of interest to American wildlife biologists is omitted. For example, Scandinavian and Russian ungulate range research is not mentioned. Likewise there is no comment on the large body of Russian and Scandinavian winter ecology work.

I feel that there should have been some discussion of the better-known "wildlife" research institutes of Europe. Some coverage of institute programs, and institute policies relating to visiting scientists, would have been valuable, particularly for North American biologists without contacts in Europe at present.

In spite of what I have said previously, this is a valuable book. As Dagg states in the Preface, "we may be enlightened not only by examining the approach of Europeans to wildlife management, but by considering their attitudes to the game itself." Wildlife administrators, conservationists, and the general reader will benefit from this book. The chapters on extinction, pollution, legislation, non-game species, conservation, and aesthetics have general appeal. Discussions of the history and population development of many species, including introduced species, will provide much material for university courses. All biologists will develop real enthusiasm for the 679 fully referenced titles in the bibliography.

In North America the memory of the pioneer moving through the unlimited game-filled wilderness dies hard. But the acceptance of 'privilege' over 'right' is making some headway among the hunting fraternity. Although it seems unlikely that our human population density will reach that of Europe, pressures of our environment will continue to affect wildlife. The European experience can be valuable to us. This book will help many North Americans realize this. If you are reading this review you should also read the book.

Tom Northcott

Northland Associates Ltd., P.O. Box 1734, St. John's, Newfoundland A1C 5P5

The Bluebird. How can you help its fight for survival

By L. Zeleny. 1976. Indiana University Press, Bloomington. 170 pp., illus. $7.95.

When I first bought this book, in the fall of 1976, I was disappointed with it. The sketches were attractive but the color plates seemed to lack the brilliant hues of our most colorful thrush.

Now, in January 1978, I have come to like this work. Most of what I have learned along my nest-line of 500 boxes is confirmed herein. I have never raised young bluebirds but the author has, and the story is valuable.

Sialia sialis does not overwinter in my area, so I do not know what food to supply to keep them alive in cold weather. It appears that the imported starling eats all of the soft berries from the shrubs before the bluebird has arrived from the northern parts of its range. This is a solid reason to shoot starlings or otherwise kill them.

I had 31 townships covered by bluebird nesting boxes but I was driven out of 21 townships by sparrows, or by sparrows plus vandalism. Another reason for naturalists to use guns or some type of humane trap or some chemical that repels the foreign birds.

We learn, in the book, how tobacco-curing kilns killed two million bluebirds and how diligent citizens wrapped steel mesh around the chimneys to prevent more deaths.

Altogether, this is a fine work but I do hope that future editions will contain some really sparkling color plates.

L. A. SMITH

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The African Buffalo. A study of resource limitation of populations

By A. R. E. Sinclair. 1977. Wildlife Behavior and Ecology Series, University of Chicago Press, Chicago and London. 355 pp., illus. $20 U.S.

This first-rate book by Sinclair, who now teaches at the University of British Columbia, tells the reader not only all he wants to know about the African buffalo, but a great deal about the ecology of central East Africa as well. The text zeros leisurely in toward its main subject via the evolution of various members of the Bovini tribe, the ecology of the areas where the study took place (primarily Serengeti National Park, Lake Manyara Park, and Arusha Park), and the resource requirements of the buffalo. The daily activity, social behavior, reproduction, and growth of the buffalo are then considered in detail before the author broadens his scope again to consider the basic problem of whether such a herbivorous population can regulate its own numbers, and if so, how. Indeed this book could serve as a text for students of population ecology because of its breadth of vision.

The modern approach to studying wildlife species, via their ecology in the widest sense, is an excellent one which contrasts markedly with earlier studies in which an enthusiastic observer watched and recorded what the members of "his" species were doing for a few months or a year, then wrote up his notes with little thought for the broad principles that lay behind his observations. Sinclair's approach required both time (six years of field work) and immense resources. He acknowledges financial aid from five different sources, and immediate practical help from a variety of behaviorists, pathologists, veterinarians, botanists, and chemists. His work included radio-telemetry studies on buffalo, taking a number of censuses by airplane, and even visiting Australia to work on wild buffalo there. It was obviously a tremendous undertaking.

It is impossible in a short review to discuss Sinclair's work in depth, but a mention of some of his findings will give an idea of the range of his research.

1. Old buffalo, which chew more slowly than young ones, are unable to compensate for the poor grinding efficiency of their teeth by increasing the amount or rate of chewing.
2. Buffalo tolerate hot weather to some extent by increasing their body temperature diurnally, but the increase is less than in some ungulates such as the camel.
3. Herd animals move daily two or three times the distance covered by bachelor males, and thereby use up 4–7 percent more energy, but herd animals suffer less predation.
4. Lions, the only important predator of buffalo, account for only 30 percent of the total number of buffalo deaths.
5. Buffalo are hosts to at least 57 species of endoparasites and 17 species of ectoparasites.
6. The crude density of buffalo was positively

correlated with rainfall, and hence food supply, which indicates that the populations were regulated.
7. A lack of food (primary factor) leads to undernutrition and impaired immunity to disease in buffalo. Diseases may then become pathogenic (secondary factor) and cause a host's death.

The format of this book is good, with the main findings of each chapter summarized succinctly. The many figures are included in the text, which is as it should be, but unfortunately the tables are all grouped in an appendix. The black-and-white photos too are not included in pertinent places in the text where one would like to see them, but clumped in one place. An appendix lists the common and scientific names of the animals mentioned in the book, but little effort is made to take advantage of this feature because both names are also usually given in the text itself. A list of scientific names of plants is given, but their common names are omitted.

ANNE INNIS DAGG

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Proceedings of the 1975 Predator Symposium

Edited by R. L. Phillips and C. Jonkel. 1977. Montana Forest and Conservation Experiment Station, University of Montana, Missoula. 286 pp. $4.00.

As part of the 55th Annual Meeting of the American Society of Mammalogists, a Predator Symposium was held. This text contains 18 of the 19 papers presented at that symposium, along with one other paper that the editors felt was appropriate to the topic.

The papers cover predator–prey relationships, predator management, behavior and interspecific relationships of predators, and predator biology. "Some papers deal with the general biology of predators while others discuss the complications of predator management in today's society." The papers all follow the format of the Journal of Wildlife Management and most are worthy of publication therein.

The papers "deal with a wide variety of species, ranging from anteaters in central America to wolves in Alaska." Some of the predators considered are dogs, Mountain Lion, Mink, Fisher, Red Fox, Black Bear, Spotted Hyena, Coyote, and Polar Bear. The symposium was not dominated by consideration of any one predator species at the cost of all others.

A paper by Gipson and Sealander, *The ecological relationships of White-Tailed Deer and dogs in Arkansas*, points out that "dogs appeared to be relatively inefficient predators as compared with wolves, cougars, and possibly coyotes and coyote hybrids." Their study was designed to examine the effects of repeated harassment by dogs on deer.

Eberhardt and Sargeant's paper, *Mink predation on prairie marshes during the waterfowl breeding season,* attempted to define the impact Mink can have on waterfowl production. In their study area, it appears that 78 percent of the vertebrates consumed by Mink were birds, with most of these being waterfowl.

Mech's paper, *Population trend and winter deer consumption in a Minnesota wolf pack*, attempts to analyze "the numbers, net productivity, winter activity, territory size and winter predation rate of a wolf pack in the west-central Superior Forest." This excellent paper alone is well worth the purchase price of the book.

The papers of this symposium suggest that a general shift in wildlife management attitude has taken place. Wildlife managers are no longer attempting to eradicate predator species; rather they are attempting to control predators. This attitude is most clearly seen in Pils' paper, *A case against Red Fox reduction in Wisconsin.*

One of the hardest tasks facing wildlife managers today is that of public education. The tradition of aversion to predators has been well entrenched in the public mind. To the hunting public, predators are seen as competitive on the natural resource. To the farming-ranching public, predators are seen as a capital risk factor which directly reduces their operational capital.

Generally speaking, the text contains an excellent collection of papers. It is unfortunate that the proceedings release date must follow the symposium by approximately two years, a delay period of greater than that of most journals.

PETER CROSKERY

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ENVIRONMENT

The John Dorr Nature Laboratory: Management for ecological values

By Karen Cathey, Susan Cooley, and Kate Ligare. 1976. Yale University School of Forestry and Environmental Studies, New Haven, Connecticut. 64 pp., illus. Paper $3.

John Dorr was an inventor and industrialist who had a keen interest in conservation and natural history. In 1965 Mrs. Dorr presented 35.2 hectares of forestland to the Horace Mann-Barnard School, Riverdale, New York for use as an outdoor center for young people. This site was named The John Dorr Nature Laboratory in honor of her husband.

This 64-page publication is the work of three graduate students from Yale School of Forestry and Environmental Studies who surveyed the natural resources of a 730-hectare tract of land in northwestern Connecticut. Special attention was given to The John Dorr Nature Laboratory which formed part of the tract.

The purpose of the publication is twofold. First, it combines a study of the natural resources of the region with a discussion of the general ecological principles involved. Second, it describes and assesses the educational potential of The John Dorr Nature Laboratory. The publication succeeds on both counts.

It is an attractive book, large (8½ × 11″), with a soft cover, and profusely illustrated with photographs, sketches, diagrams, and maps (only 5 of the 64 pages are without illustrations). The low-key text is excellent.

Basic ecological concepts (each of the book's seven sections are built around a particular concept: succession, limiting factors, communities, and so on) are presented accurately and clearly, and related to the Connecticut study area. It is an excellent treatment of the natural resources and management considerations of the region.

Floral and faunal species lists are provided. I was pleased to see that scientific as well as common names are given. There is also a bibliography of 130 titles ranging from local history through wildlife and ecology to alternative sources of energy. I was particularly encouraged to note this latter.

The educational potential of the Dorr Laboratory is considerable. This is made clear in the book. The discussion of present and potential use of the area clearly shows that the Laboratory's program is a multi-disciplinary one. The whole program is based on ecological principles, and on stewardship for the environment. It combines traditional concepts of ecology with progressive attitudes of alternate technology (utilizing solar or wind power). The book, and the Dorr Laboratory, can serve as useful models to any agency considering establishment of a nature center.

TOM H. NORTHCOTT

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The Ecology of the Seas

Edited by D. H. Cushing and J. J. Walsh. 1976. Saunders, Philadelphia. 467 pp. $19.50.

This book is a collection of essays by some of the best known marine ecologists and fisheries scientists of our day who were brought together for this task by Cushing and Walsh. The keynote of the book is, the editors believe, that marine ecology is now well enough advanced as a quantified science to develop refutable hypotheses, and that hypotheses are needed to understand the ecological processes of the sea, as well as to define the discipline of marine ecology.

The text is divided into six sections: The Sea and the Organisms, a somewhat descriptive section; The Structure of Life in the Sea, in which the authors discuss the structure of plankton communities; Functions in the Marine Ecosystem, a group of essays dealing with various levels of marine production; Yield from the Sea, i.e., fish; Evolutionary Consequences, that is, competition and isolating mechanisms; and Theory, or to use the editors' earlier and better terminology, 'hypothesis.'

There is a logical stepwise progression of development in the book from a very detailed and advanced description of the physical and biotic properties of the sea to production of populations, stability of ecosystems, and a hypothesis which encompasses these processes. One of the strongest points of the book is its extensive up-to-date bibliography. This will be extremely helpful for introducing scientists and students to the primary scientific literature dealing with the oceans.

For those interested in an advanced treatment of marine plankton ecology and its relation to fisheries, this book is excellent. It is, however, too advanced for most general readers. The book would make a good text for a senior-level university course, especially for students interested in quantitative ecology.

To my mind the book has been inappropriately titled. It should have been called "The Ecology of Pelagic Fisheries Food Chains." To title it "The Ecology of the Seas," but never discuss intertidal ecosystems (except for a brief mention in the chapter by K. H. Mann) or coral reefs, is misleading. These two ecosystems are major production centers in the world's oceans; the intertidal ecosystem is one of the major suppliers of organic carbon to shelf waters and is therefore of major importance to pelagic food chains. On the other hand, complete chapters are devoted to vertical migration and patchiness, which are problems specific to plankton studies and to fish growth, a topic the editors could have more appropriately touched by referring the reader to the many available texts. Also, the editors state that 98% of marine organisms are benthic but include only one chapter on this subject, and that devoted largely to commercially important benthic invertebrates.

There is one last complaint, which depending on the reader's interests may be either large or small. The book lacks explanations. The authors assume that the general reader is more knowledgable than in fact he may be, and therefore they omit many of the explanations which could have been included. For instance, the wind El Niño is mentioned three times (the second time wrongly paginated in the subject index, the third not referenced at all (see page 402)), but the writers never digress for even that one sentence to tell an uninformed reader what, where, why, and when this wind occurs. The fact that it can periodically change the entire current structure off the coast of Peru, cause a collapse in the anchoveta stocks and the associated fishery, are tidbits hidden from the reader. This is especially disconcerting because in the last chapter this very system is used as one of the data bases for the ecosystem hypothesis model.

Every practising or potential marine ecologist, as well as anyone interested in zooplankton, should read this book. The ecological principles expounded are nicely summarized and put to the reader succinctly. Oceanic physics, nutrient cycling, primary and secondary production of the pelagic zone, and fisheries production are convincingly tied together. Within its subject area this book will be a major reference text for years to come; unfortunately, it cannot be considered a general marine ecology text.

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Arctic Journey. Paintings, sketches and reminiscences of a vanishing world

By Peter Buerschaper. 1977. MacMillan, Toronto. 126 pp., illus. $14.95.

The purpose of the expedition was to provide an artistic record of the animals and birds in our last frontier, the high Arctic, within their natural setting as seen only by a few hardy explorers, scientists, and Inuit. The purpose is well fulfilled, but I feel it is even surpassed by the sense of wonder and awe portrayed in the accompanying diary of the journey. Some may wonder that so much can be seen and accomplished in a few short weeks, but those who have had the privilege can only envy the ability to describe the ever changing variety of the arctic spring in such an accurate and yet highly enjoyable manner.

Buerschaper's prints and sketches provide an excellent detail of a representative sampling of the variety of life in the high Arctic. It is especially intriguing to see the presentation of many smaller birds and mammals performing spring behavior patterns within the background of their own special microhabitats. Often these less noticeable species receive less than their due since they are much harder to find and more difficult to photograph without disturbing them in their natural setting.

Besides the interesting artwork, Buerschaper's diary is recommended reading to any who would or have experienced the wonder of the arctic environment. His 3-week expedition to Resolute and Bathurst is filled with the excitement of a first-time venture into the unknown. It vividly portrays the wonder and awe of a first experience of spring in the Arctic. It warns the novice of the frustrations of weather or delays in transportation, but also emphasizes the satisfactions that a dedicated naturalist can expect. It illustrates how one must accommodate oneself to the differences in the way of life at an isolated village such as Resolute, or even more lonely arctic research camp, but it also shows just how much can be accomplished in a short period, if one is willing to work and adapt. It should also remind the seasoned veterans of how lucky they are to experience so much that has been seen by so few.

This book is readable, enjoyable, and highly esthetic. It is packed with both casual observations and ecological knowledge. It is recommendable reading to any with an interest or desire for faraway places.

WILSON EEDY

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OTHER

The Backpacker

By Albert Saijo. 1977. 101 Productions, San Francisco. (Canadian distributor Van Nostrand Reinhold, Toronto.) 192 pp. Paper $3.50.

This little book is both an introduction to backpacking and a comment on the development of a "style" for hiking in the wilderness. Eight chapters deal with equipment, food, trip planning, and various aspects of the trip itself.

Saijo's mystical regard for the wilderness becomes clear early in the book and his views on various aspects of backpacking are evident throughout. Unfortunately, these views are sometimes expressed at the expense of being objective, which could leave the inexperienced backpacker either poorly advised or confused. For example, the poncho is presented as a versatile and essential item for protection against rain, but no mention is made of its disadvantages nor is there a discussion of the two-piece rain suit which many hikers prefer. Most major items of equipment are covered adequately, but tents and stoves receive incomplete treatment. A comparison of gas-fueled and cartridge stoves fails to mention the poor operation of the latter type at low temperatures.

The author stresses the point that individual preference will play a major role in food selection, but his sample recipes strongly emphasize seeds, grains, and fruits obtainable at health and natural food stores. In fact, many backpackers would take issue with his statement that "supermarkets have surprisingly little you'd want to take into wilderness" (p. 104). Other statements of questionable basis include: "There is no reason at all to get hurt in wilderness" (p. 79), "burn used toilet paper" (p. 176), "note that moss grows on the north side of trees" (p. 156), and the comment on page 162 that the only animal besides ourselves that will attack without provocation is the dog, which we've trained to express our hostilities.

The author's style of writing includes the use of nonsentences and there are several cases of omitted conjunctions and unusual phraseology, but his meaning is usually clear. The book is essentially free of proofreading errors. A totally new set of black-and-white drawings, which are interspersed throughout the book, is the major difference between this and the 1972 edition. Reorganization and addition of material has been done in some chapters.

If one realizes that *The Backpacker* contains many opinions and reads it with an open mind, then this book can be an interesting and useful introduction to the subject. At a time when there is such a proliferation of often expensive and unnecessary backpacking equipment, Saijo's advice to travel light should be carefully considered.

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NEW TITLES

Zoology

†**Art anatomy of animals.** 1977. By Ernest Thompson Seton. Reprint of 19th century edition. Running Press, Philadelphia. 200 pp., illus. Paper $5.95.

Biology of benthic organisms. 1977. Edited by B. F. Keegan and P. O. Ceidigh. Proceedings 11th European Symposium on Marine Biology, 5–11 October, 1976, Galway, Ireland. Pergamon, Elmsford, New York. 630 pp., illus. $50.

Biology of the Reptilia. Volume 6, morphology, part E. 1977. Edited by C. Gans and T. S. Parsons. Academic, New York. 505 pp., illus. $38.

Birds in boreal Canada. 1977. By Anthony J. Erskine. Canadian Wildlife Service Report Series, Number 41. Supply and Services Canada, Ottawa. 71 pp., illus. Paper $5 in Canada; $6 elsewhere.

Birds in peril: a guide to the endangered birds of Canada and the United States. 1977. By J. P. F. MacKenzie. McGraw-Hill, Toronto. 191 pp. $14.95.

Birds of prey. 1976. By Michael Evertt. Putnam, New York. 128 pp., illus.

Deer of Nova Scotia. 1977. By D. W. Benson and G. D. Dodds. Nova Scotia Department of Lands and Forests, Halifax. 92 pp. Free?

Dolphins, whales and porpoises. 1977. By D. J. Coffey. Macmillan, New York. 223 pp. $17.95.

Ecology and behaviour of nocturnal primates. Prosimians of equatorial west Africa. 1977. By P. Charles-Dominique. Translated by R. D. Martin. Columbia University Press, New York. x + 278 pp., illus. $17.50.

Ecology of marine benthos. 1977. Edited by B. C. Coull. Papers from a symposium, Georgetown, South Carolina, May 1975. Bell W. Baruch Library in Marine Science, No. 6. University of South Carolina Press, Columbia. xx + 468 pp., illus. $27.50.

†**Faunal remains from Fort White Earth N.W.Co. (1810–1813).** 1977. By Isobel Hurlburt. Human History Occasional Paper No. 1. Provincial Museum of Alberta, Edmonton. vii + 107 pp. Paper free.

Fish remains in archeology and paleoenvironmental studies. 1977. By R. W. Casteel. Academic, New York. 180 pp. $16.80.

Fresh and salt water fishes of the world. 1976. By E. C. Migdalski. Knopf, New York. 316 pp., illus.

Grasshoppers and locusts. A handbook of general acridology. Volume 2, behaviour, ecology, biogeography, population dynamics. 1977. By Boris Uvarov. Centre for Overseas Pest Research, London. x + 614 pp., illus. $40.

A guide to eastern hawk watching. 1976. By D. S. Heintzeman. Penn State University Press, University Park. 99 pp. Paper $5.95.

Handbook of birds of Europe, the Middle East and north Africa. Volume 1. The birds of the western palearctic. 1977. Edited by S. Cramp and K. E. L. Simmons. Oxford University Press, New York. 732 pp. $55.

Improving fish and wildlife benefits in range management. 1977. Edited by J. E. Townsend and R. J. Smith. U.S. Department of the Interior, Washington. 118 pp.

The langurs of Abu. Female and male strategies of reproduction. 1977. By S. B. Hardy. Harvard University Press, Cambridge, Massachussetts. xx + 362 pp., illus. $17.50.

The Lepidoptera of Norfolk Island. Their biogeography and ecology. 1977. By J. D. Holloway. Series Entomologica Volume 13. Junk, The Hague. vi + 292 pp., illus. Dfl.85.

†**Middle eocene freshwater fishes from British Columbia.** 1977. By Mark V. H. Wilson. Life Sciences Contribution Number 113. Royal Ontario Museum, Toronto. 61 pp., illus. Paper $3.

The origin and early evolution of animals. 1977. By E. D. Hanson. Wesleyan University Press, Middletown, Connecticut. x + 670 pp., illus. $35.

Primate ecology. Studies of feeding and ranging behavior in lemurs monkeys and apes. 1977. Edited by T. H. Clutton-Brock. Academic, New York. 631 pp., illus. $41.

Problems in vertebrate evolution. 1977. Edited by S. M. Andrews, R. S. Miles, and H. D. Walker. Papers from symposium, London, January 1976. Linnean Society Symposium Series, No. 4. Academic, New York. xii + 412 pp., illus. $36.10.

Proceedings of Perdix I Hungarian Partridge Workshop, 28 February to 3 March, 1977, Minot, North Dakota. 1977. Edited by G. D. Kobriger. North Dakota Game and Fish Department, Dickinson. 233 pp. $2.50 + 41¢ postage.

Quantitative methods in the study of animal behavior. 1977. Edited by B. A. Hazlett. Proceedings of a symposium, Chicago, 13 November 1976. Academic, New York. 222 pp., illus. $12.50.

Sea otters and seaweed. 1976. By Patricia Lauber. Garrard, Champaign, Illinois. 64 pp., illus.

A season of birds. 1976. By Dion Henderson. Illustrated by Chuck Ripper. Tamarack Press, Madison, Wisconsin. 87 pp., illus.

Transactions of the 42nd North American Wildlife and Natural Resources Conference, Atlanta, Georgia, 5-9 May 1977. 1977. Edited by K. Sabol. Wildlife Management Institute, Washington. 523 pp., illus. Paper $8.50.

†**Why big fierce animals are rare.** An ecologist's perspective. 1978. By Paul Colinvaux. Princeton University Press, Princeton, New Jersey. viii + 256 pp. $9.50.

Wildlife in the garden. 1977. By R. Genders. Faber and Faber, Salem, New Hampshire. 232 pp. $7.95.

Winter birds of the Carolinas and nearby states. 1977. By Michael A. Godfrey. Blair, Winston-Salem, North Carolina. xxiv + 136 pp., illus.

The world Oestridae (Diptera), mammals and continental drift. 1977. By N. Papavaro. Junk, The Hague. viii + 240 pp., illus. Dfl. 75.

Botany

Aquatic weeds in south east Asia. 1976. Edited by C. K. Varshney and J. Rzoska. Proceedings of a Regional Seminar on Noxious Aquatic Vegetation, New Delhi, 12–17 December 1973. Junk, The Hague. 396 pp., illus. Dfl. 110.

Better trees for metropolitan landscapes. 1976. Edited by E. S. Santamour, H. D. Gerhold, and S. Little. Technical Report NE-22. U.S. Forestry Service, Washington. 256 pp. Paper $3.25.

Carex in Saskatchewan. 1977. By John H. Hudson. Bison, Saskatoon. 193 pp., illus. Paper $10 + 50¢ postage.

†**Grassland simulation model.** 1978. Edited by George S. Innis. Ecological Studies 26. Springer-Verlag, New York. xxvi + 298 pp., illus. $22.80.

***A guide to the literature on the herbaceous vascular flora of Ontario.** 1977. By James L. Hodgins. Available from author, 90 Wolfre Avenue, Toronto. 25 pp. Paper $2.

Multivariate analysis in vegetation research. 1978. By L. Orloci. 2nd edition. Junk, The Hague. viii + 450 pp. Dfl. 100.

North American forest history: a guide to archives and manuscripts in the United States and Canada. 1977. Compiled by R. C. Davis. Clio Books, Santa Barbara, California. xxi + 376 pp.

†**The rare vascular plants of Ontario/Les plantes vasculaires rares de l'Ontario.** 1977. By George W. Angus and David J. White. Syllogeus No. 14. National Museums of Canada, Ottawa. 64 pp. English + 67 pp. French. Paper free.

The world's worst weeds. Distribution and biology. 1977. By L. G. Holm, D. L. Plucknett, J. V. Pancho, and J. P. Herberger. University Press of Hawaii, Honolulu. 609 pp. $35.

Environment

Applied ecology: a nontechnical approach. 1976. By Alden D. Hinckley. Macmillan, New York. x + 342 pp., illus. $8.75.

The art of Glen Loates. 1977. By P. Duval. Prentice-Hall, Toronto. 189 pp., illus. $35.

Biogeochemistry of a forested ecosystem. 1977. By G. E. Likens. Springer-Verlag, New York. 160 pp. $9.80.

Biogeography and ecology of southern Africa. 1977. Edited by M. J. A. Werger. Junk, The Hague. 2 volume set, 1420 pp., illus. Dfl. 365.

Biohazard. 1977. By M. Rogers. Knopf, New York. xiv + 210 pp. $8.95.

The camper's guide to Alaska, the Yukon and northern British Columbia. 1976. By Raymond Bridge. Scribner, New York. vi + 169 pp., illus.

The chemistry of our environment. 1977. By R. A. Horne. Wiley-Interscience, New York. 784 pp. $27.50.

Ecological (biophysical) land classification in urban areas/ Classification écologique (biophysique) du territoire dans les régions urbaines. 1977. Edited by E. B. Wilken and G. R. Ironside. Ecological Land Classification Series, No. 3. Supply and Services Canada, Ottawa. xiv + 167 pp. $4.

Ecology. The experimental analysis of distribution and abundance. 1977. By Charles J. Krebs. 2nd edition. Harper and Row (Canadian distributor Fitzhenry and Whiteside, Toronto). 704 pp. $16.95.

Ecosystem modeling in theory and practice: an introduction with case histories. 1977. By C. A. S. Hall and J. W. Day, Jr. Wiley, New York. 684 pp. $29.95.

Effects of petroleum on arctic and subarctic marine environments and organisms. Volume 2, biological effects. 1977. Edited by D. C. Malins. Academic, New York. 500 pp., illus. $14.50.

Energy and the environment: a risk benefit approach. 1976. Edited by H. Ashley, R. L. Rudman, and C. Whipple. Pergamon, New York. x + 306 pp. $12.50.

Energy and the environment. A structural analysis. 1976. Edited by A. P. Carter. Brandeis University Press, Hanover, New Hampshire. xviii + 262 pp. $12.50.

Environmental analysis. 1977. Edited by G. W. Ewing. Proceedings of a conference, Philadelphia, 15-18 November 1976. Academic, New York. 344 pp., illus. $18.50.

Environmental impact assessment in Canada: processes and approaches. 1977. Edited by M. Plewes and J. B. R. Whitney. Proceedings of a conference, Toronto, February 1977. Institute for Environmental Studies, University of Toronto, Toronto. $5.

†**The environment of Amchitka Island, Alaska.** 1977. Edited by M. L. Merritt and R. G. Fuller. U.S. Energy Research and Development Administration Publication TID-26712. National Technical Information Service, Springfield, Virginia. xii + 682 pp., illus. $20 in U.S., $40 elsewhere.

Histoire et nature. 1976. Anonymous. Laboratoire d'Ethnobotanique 8. Musée d'Histoire naturelle, Paris. 88 pp. Paper 50F.

†**Lore and legends of Long Point.** 1977. By Harry Barrett. Burns and MacEachern, Toronto. 240 pp., illus. $14.95.

Our fragile water planet. 1976. By C. L. and A. M. Mantell. Plenum, New York. 275 pp. $19.50.

Patterns of evolution as illustrated by the fossil record. 1977. Edited by A. Hallam. Elsevier, New York. xiv + 592 pp., illus. $69.50.

Public involvement in natural resource planning and decision making: a selected bibliography. 1976. Council of Planning Librarians, Monticello, Illinois. $1.50.

The southern Appalachians. A wilderness quest. 1975. By C. Ogburn. Morrow Paperback, New York. 245 pp. Paper $5.95.

Sulfur, energy and environment. 1977. By B. Meyer. Elsevier, New York. xii + 448 pp., illus. $39.60.

***The wild shores of North America.** 1977. By Ann and Myron Sutton. Knopf (Canadian distributor Random, Toronto). 240 pp., illus. $43.

When values conflict: essays on environmental analysis, discourses and decision. 1976. Edited by Laurence H. Tribe, Corinne S. Schelling, and John Vass. Ballinger, Cambridge, Massachusetts. xv + 178 pp.

World within a world — Everglades. 1976. By T. Lewin. Dodd, Mead, New York. 64 pp., illus.

Miscellaneous

Alternate energy strategies: constraints and opportunities. 1976. By J. Hagel III. Praeger, New York. xii + 185 pp.

The center of life: a natural history of the cell. 1977. By L. L. Cudmore. Quadrangle, New York. 176 pp. $8.95.

Implementing solar energy technology in Canada: the costs, benefits and role of government. 1977. By M. K. Berkowitz. Renewable Resources Branch Report EF-77-71. Supply and Services Canada, Ottawa. 239 pp.

Land and land appraisal. 1976. By R. O. Whyte. Junk, The Hague. xiv + 376 pp., illus. Dfl. 100.

The nuclear power debate. Moral, economic, technical and political issues. 1977. By D. Myers III. Praeger, New York. xiv + 158 pp. $15.

***Photography for the joy of it.** 1977. By Freeman Patterson. Van Nostrand Reinhold, Toronto. 168 pp., illus. Cloth $19.95; paper $9.95.

*assigned for review
†book received and available for review

The Ottawa Field-Naturalists' Club

Minutes of the Ninety-eighth Annual Business Meeting of The Ottawa Field-Naturalists' Club

The 98th Annual Business Meeting of The Ottawa Field-Naturalists' Club was held in the auditorium of the National Research Council, Sussex Drive, on 31 January 1977. The President, E. C. D. Todd, called the meeting to order at 8:08 p.m., with a quorum of 34 persons present (the final total was 39). The Recording Secretary read the minutes of the 97th Annual Meeting, which were approved on motion (by R. Taylor, 2nd M. Brigham).

E. Todd referred to business arising from those minutes. The Club's 1975 financial statement, which had not been ready for approval at the last Annual Meeting, was subsequently received and approved by Council, for the Club, and published in *The Canadian Field-Naturalist*, as had been arranged at the 97th Annual Business Meeting. As suggested at the last Annual Meeting, a meeting featuring a panel discussion on the pros and cons of land acquisition by naturalists' organizations was organized by George Neville, and held on 14 September 1976. At the annual meeting of the Canadian Nature Federation, the Club assisted by organizing and leading excursions, and by helping at the registration of delegates.

In the absence of the Treasurer, R. Foxall called on M. Brigham, the Club's accountant to present the 1976 financial statement. A few items of expenditure were queried, but the accountant pointed out that most of the major amounts were relatively fixed costs, so that even if the minor categories under discussion were eliminated, this would not appreciably influence the overall totals. In discussion, G. Neville criticized the handling of the 1975 financial statement, but it was agreed that that irregularity had no effect on acceptance of the 1976 statement, which was approved on motion (by W. Cody, 2nd H. MacKenzie).

The Annual Report of Council, to be published in *The Canadian Field-Naturalist*, was introduced by E. Todd. He commented on some of the highlights, such as the adjustment of the proportion of monies allocated to the Club and *CF-N* after the decrease in numbers of non-local members, who had instead become subscribers to the journal; difficulties of the Conservation Committee in dealing with the many issues arising; the co-chairmanship, with the National Museum of Natural Sciences, of the Macoun Club, and the recent appearance of the 1976 *Little Bear*; the assistance of Club members at the Ottawa Duck Club open house, for which a letter of thanks was recently received; support of a third winter bird feeder (in Lucerne); and approval of new by-laws. The report was approved by M. Brigham, 2nd D. McClymont. In discussion, C. Gruchy queried the number of individual subscribers to *CF-N*; W. Cody reported this to be 277, thus almost equalling the net decrease (284) in Club membership. Mention of the publication *Shrike* as a part of the Publications Committee report was queried, and on motion (by D. A. Smith, 2nd L. C. Smith) this reference was to be put elsewhere in the Annual Report of Council. The status of *Shrike* as a Club publication had been debated by Council, but it had never been referred to the Publications Committee. G. Neville moved (2nd L. C. Smith) that 'the matter of the 1976 Council's endorsement of the publication of *Shrike*, by permitting the Club's name to be attached thereto, be referred back to Council for direction to the Publications Committee for a recommendation on this matter in the Club's interest'; this was approved 15 to 9 (with numerous abstentions). D. Gray queried whether *Little Bear*, which in 1976 received financial support from the Club, should also be discussed by the Publications Committee. It was agreed that this was not called for, as it is a publication of the Macoun Club, not OF-NC. G. Neville queried the procedures of the Conservation Committee, and recommended that it be noted that no Club or Council approval should be given to reports or briefs of this Committee not previously cleared; the question of whether this recommendation is at odds with the Club's delegation of responsibility to Council and the President, and with Council's delegation to the Committee and its Chairman, was left open. Approval of the Annual Report of Council, as amended, was then given.

Todd then called on M. Ney, as chairman of the Nominating Committee, to present the slate:

President: Roger Foxall; Vice-President: Roger Taylor; Treasurer: Barry Henson*; Recording Secretary: Diana Laubitz; Corresponding Secretary: Sally Armstrong; additional members of Council: Elisabeth Beaubien, William Cody, Jane Diceman, Albert Dugal, Anthony Erskine, Charles Gruchy, Jeffrey Harrison, Hue MacKenzie, Jo Anne Murray, Marshall Ney, Gavin Nicholson, Gerald Oyen, Gilles Patenaude, Kenneth Strang, Stanley Teeple, Ewen Todd (Past-President), Stan van Zyll de Jong.

No additional nominations were received in response to an appeal published in *Trail & Landscape*. Following approval of the slate, Todd thanked the members of the 1976 Council who were retiring after the meeting: David Gray, Diane McClymont, Patricia Narraway, Pamela Sims.*

*As the result of a misunderstanding, Mr. Henson declined to act as Treasurer, and Ms. P. Sims was co-opted to that office by the Council in February 1977.

The auditors for 1977, G. J. Wasteneys and D. A. Potter, were approved on motion (by R. Foxall, 2nd H. MacKenzie).

Todd then called on H. MacKenzie to report for the Centennial Steering Group. MacKenzie noted that Council had been asked for, and had given direction on, planning policies; the Group now had 27 proposals on hand (compared to 19 a year ago), of which only three or four have been eliminated; some projects need a long lead time and others very little, but all need active leaders; an overall Public Relations co-ordinator will also be essential. G. Neville suggested polling Club opinion on various topics rather than leaving all decisions to Council, and L. C. Smith urged a special general meeting on the subject after the projects had been chosen; appeals in *Trail & Landscape* or at the Annual Dinner were also suggested for enlisting interested persons to work on various projects.

Todd called attention to the public hearings, before the Ontario Municipal Board, of the Ottawa-Carleton Region official plan, to start 14 February 1977, and to continue for several months. Appeals have been launched on many points, including a number of the designated conservation areas, most of which stemmed from recommendations of the Club's committees in past years. It is probable that the Club's role will be to brief the City of Ottawa and Region officials regarding details of natural values in areas that have been challenged, rather than directly contesting the challenges. Volunteers for any necessary action are needed, but the schedule of relevant hearings is still uncertain.

In closing, Todd thanked the membership for the opportunity of his two and a half years as President, and expressed thanks also to various individuals for their efforts, those named being R. Foxall, A. Erskine, W. Cody, H. MacKenzie, and C. O'Keefe.

The incoming President, R. Foxall, thanked Todd for his excellent service as President, and expressed his own enthusiasm for the planning that will lead up to the Club's centennial celebration in 1979.

Adjournment of the meeting (on motion by G. Wasteneys) was at 10:29 p.m.

In view of the late hour, no entertainment was presented following the refreshments.

A.J. ERSKINE, Recording Secretary

Report of Council to The Ottawa Field-Naturalists' Club

During 1977 there have been meetings and discussions between the Club and the Department of National Defence on the matter of access to Shirleys Bay. We have now received notice of the conditions under which we might be granted access; in September 1977 the Council approved the start of preliminary negotiations on a contract.

Action has also been taken in the matter of a "corporate memory," and statements of responsibilities of the committees, officers, and servants of the Club are being drawn up for approval by the Council.

Preparations for our Centennial continue, and the **Centennial Steering Committee** brought three projects before the Council for approval: *The Orchids in the Ottawa District;* an *Index* to *The Transactions of The Ottawa Field-Naturalists' Club* and *The Ottawa Naturalist;* and a reprint of the *Autobiography of John Macoun.* Other project leaders will be presenting their proposals in the coming months. The June meeting of the Club discussed the Centennial, and a number of useful ideas and suggestions resulted. A major proposal was that a conference should serve as a focal activity, with other functions, such as exhibitions and competitions, taking place at the same time. Regrettably few volunteers have come forward to work on or help co-ordinate Centennial projects. As a result, some may have to be discarded owing to lack of active support. Financing the Centennial will be one of the important activities faced by the Council in 1978. A volunteer willing to serve as a Ways and Means chairman for this purpose is currently being sought. (H. MacKenzie)

Finance Committee. At the 98th Annual Meeting Barry Henson was elected Treasurer; however, due to a prior commitment on Monday evenings, he would have been unable to attend a Council meeting before September. He resigned from the post, and Council appointed the former Treasurer, Pamela Sims, to a third term. The Committee expresses its appreciation to Mrs. Sims. Early in 1977 the budget was prepared, and adopted by Council. A number of recommendations made by the auditors, concerning accounting procedures, as adopted. The most significant of these was the amalgamation of the seven bank accounts into one. One of the auditors, Doug Potter, also pointed out that the Club could profitably make use of 30- and 60-day term deposits. He volunteered to analyze the cash flow and arrange for the transfer of funds to these deposits, which he was authorized to do. More than $1000 was gained in interest during the past financial year, most of it going to *The Canadian Field-Naturalist.* We are grateful to Mr. Potter for his

recommendation and action, and we strongly recommend the continuance of this investment policy. In view of the deficit budget presented to Council, and of the current high rate of inflation, it was felt that the $2.00 increase in membership fees that had been recommended would prove inadequate; a $3.00 increase was recommended to Council. After some debate the fee changes were passed unanimously. Doug Potter made yet one more recommendation, to change the financial year end to September 30. This is a good time to close the books, as it is a slack time in the Club's finances, and it avoids the Christmas – New Years season, thus relieving the pressure on the volunteer help on which the Club is so dependent. Council accepted this recommendation unanimously, and the 1977 financial statement covers the period January 1 to September 30. Pamela Sims expressed her desire to resign at the end of the financial year, and Council acted upon the recommendation of the Finance Committee to re-appoint Barry Henson as Treasurer. (R. Taylor)

The **Membership Committee** reported that the total membership has increased by 35 over 1976. It is with regret that the committee announces the death in November 1977 of Dr. A. E. Porsild, an Honorary member and a former President of the Club.

(M. Ney)

The **Publications Committee** reported that four issues of *The Canadian Field-Naturalist,* volume 90(4) and volume 91(1, 2, 3), with a total of 498 pages, have been published since the last report. The total number of articles and notes published during the period was 111, comprising 37 papers on birds, 36 on mammals, 14 on plants, 9 on fishes, 7 on reptiles and amphibians, 2 on insects, and 5 on other topics. The number of manuscripts submitted to the Editor in 1976 was 147; 64 book reviews were also published. Grants in support of the journal were received from the National Research Council of Canada ($5000) and the Canadian National Sportsmen's Show ($500), for which we are grateful. *Trail & Landscape* appeared in five issues totalling 152 pages of articles and information of local interest. *Shrike,* a newsletter for bird-watchers in the Ottawa area, became an official publication of the Club. Special thanks are due to Harry Thomson, who is leaving *Trail & Landscape* after 11 years of valuable and dedicated service.

(S. van Zyll de Jong)

During 1977 the **Excursions and Lectures Committee** organized 36 excursions, 10 monthly meetings, a workshop for excursion leaders, and the annual dinner. The field trips were related to birds (21), general topics (10), botany (3), mineralogy (1), and butterflies (1). The two bus excursions were highly successful, and the committee recommends that more bus excursions be organized in 1978. Statistics are now being kept on all excursions in order to assess the entire program, and to learn what factors influence the numbers of participants. It is anticipated that attendance at the monthly meetings will improve as a result of the move from the Activity Centre at the National Museum of Natural Sciences to the auditorium in the same building. The leadership workshop was a very useful exercise; however, it was clear that this workshop only scratched the surface, and that there is a great deal more to be learned. The committee considers a follow-up to this exercise in 1978 to be mandatory. The speakers at the annual dinner were Kay and Larry McKeever, the "owl people" from Vineland, Ontario. Their fascinating talk, combined with the excellent hot and cold buffet at the Talisman Motor Hotel, made a highly successful evening. (R. Taylor)

During 1977 the members of the **Conservation Committee** decided that (1) the major efforts of the committee should be concentrated within a 30-mile radius of Ottawa, but that exceptions would be made in the area beyond this where no other organization exists to take action; (2) any statements on policy, including briefs, should be approved by elected representatives of the Club before they are released;

Membership of the Ottawa Field-Naturalists' Club.

Membership	Canadian (local)	Canadian (other)	USA	Foreign
Individual	438 (408)	342 (324)	106 (85)	5 (6)
Family	207 (203)	22 (23)	2 (3)	1 (1)
Sustaining	10 (9)	3 (2)	nil	nil
Life	9 (7)	6 (4)	1 (1)	2 (2)
Honorary	5 (6)	4 (4)	nil	nil
Totals	669 (633)	377 (357)	109 (89)	8 (9)
Changes	+36	+20	+20	–1
Grand Total	1163 (1088)			

NOTE: Year 1976 shown in brackets.

(3) participation on non-Club committees that were concerned with conservation issues in the Ottawa-Hull region was valid; and (4) due to deficiencies in knowledge of natural history within the 30-mile radius area, expeditions would be held to gather information. The committee has therefore been participating in the Ontario Municipal Board hearings into conservation areas in the Ottawa-Carleton Region; in the Ontario Royal Commission on Power Planning; and in Power Planning in Eastern Ontario, organized by Ontario Hydro. At least 13 field trips were held to visit areas of concern to the committee. Many of these have proved useful, since the Ottawa-Carleton Region has recently suggested changes to the official plan in regard to conservation areas, some of which may be deleted. The committee is actively involved in considering these proposed changes, and is in close contact with the Region about them. The committee is also working towards a definition of a conservation area and the criteria that determine its value. The active participation, and deep concern for conservation shown by the members of this committee is acknowledged by the Chairman and by the Council. (E. Todd)

The **Macoun Field Club Committee** reports a very successful and productive year for the Club. Gerry Fitzgerald (NMNS) and Arnet Sheppard (OFNC) have worked very hard, making an interesting year for the Junior and Intermediate groups, with weekly meetings and monthly field trips about the Ottawa region. David Gray continued as supervisor to the senior group. They have continued with weekly meetings and field trips. Projects have been undertaken by each member, according to their interest; for example, the report on the Laverendrye canoe trip will consist of lists, notes, and descriptions of the area and its species. A trip to Point Pelee, sponsored by NMNS, was a great success; interest was very high, and a large number of members went. The Seniors have also been actively helping with the Nature Exploration Program in the Gatineau, making cross-country skiers more aware of their surroundings and of their impact on the environment. Thanks are due to the National Museum of Natural Sciences, the group chairmen, and particularly the parents who acted as chauffeurs for the Club outings. (G. Nicholson)

The **Education and Publicity Committee** continued to provide trip leaders and speakers for outside groups, and judges for the Ottawa Science Fair. An exhibit on "Ontario Bats," for the Federation of Ontario Naturalists conference in Guelph was built and 'manned' by the committee members, and received many compliments. The possibility of getting occasional feature articles in *The Citizen* is being investigated. With the approval of the Council, arrangements are being made to get a Club phone, which will be listed under our name in the directory, and for the present will be installed in Ellaine Dickson's house. (E. Beaubien)

The Moodie Drive, Davidson Road, and Pink Road (Lucerne) bird feeders continue to be supported by the Club, along with the new feeders that have been set up at the Geomagnetic Laboratory on the Anderson Road. And Club badges have been available since the spring of 1977, and are proving to be quite popular.

Thanks are extended to all those who helped with and contributed to the activities of the Club in 1977.

Compiled from committee reports
and Council minutes by
D. R. LAUBITZ, Recording Secretary

Auditor's Report

To: Members of the Ottawa Field-Naturalists' Club

We have examined the balance sheet of The Ottawa Field-Naturalists' Club as at September 30, 1977 and the related Income Statements for the nine-month period. Our examination included a general review of the accounting procedures and such tests of the records and supporting vouchers as considered necessary in the circumstances.

While the bank reconciliation has not been carried out on a month-to-month basis, the bank has been reconciled as of September 30, 1977 with the cash in bank per balance sheet.

In our opinion these financial statements present fairly the financial position of the organization as at September 30, 1977 and the result of its operations for the nine-month period in accordance with generally accepted accounting principles.

February 14, 1978

(Signed) Geoffrey Wasteneys
James Montgomery

Corrected Financial Statements — February 1, 1978

The Ottawa Field-Naturalists' Club Balance Sheet

as at September 30th, 1977

Assets

Current		
Cash in Bank & Term Deposits — OFNC		
— CFN	35,115.10	
Bills Receivable	3,116.19	
Accrued Interest Receivable	9,290.48	47,521.77
Fixed (at cost)		
Furniture, Fixtures & Equipment	529.50	
Less Accumulated Depreciation	411.52	117.98
Investments and Securities		
Canada Savings Bond		10,700.00
		58,339.75

Liabilities and Equity of Surplus

Current Liabilities		
Income Received in Advance	6,916.68	
Accounts Payable	7,489.00	14,405.68
Equity of Surplus		
Balance January 1st, 1977	38,458.80	
Add: Net Income for nine months	5,475.27	43,934.07
		58,339.75

(Signed) Geoffrey Wasteneys, Auditor
James Montgomery, Auditor
Pamela J. Sims, Treasurer

The Ottawa Field-Naturalists' Club Statement of Profit and Loss — OFNC

For the nine-month period ended September 30th, 1977

Revenue			
Membership Income		3,701.00	
Life Membership		800.00	
Donations & Grants		416.89	
Sale Income		258.65	
Subscriptions *T & L*		150.00	
Special Activities		323.66	
Interest & Income			
Bank Interest	507.28		
Canada Savings Bonds	557.73	1,065.01	
			6,715.21
Less cost of publications			
T & L (Vol. II)		2,147.25	
Circulation		87.91	
Office & Editorial		6.00	
Honoraria		330.00	2,571.16
Gross profit on Club operations			4,144.05
Less operating expenses			
Council Expenses		403.18	
Printing & Stationery		53.80	
Committee Expenses — Membership		309.38	
— Excursions & Lectures		266.52	
— Publications		4.40	
— Bird Records (net)		(28.04)	
— Bird Feeder		248.03	
— Research, Briefs & Conservation		30.55	
— Education		8.07	
— Macoun Club		470.74	
— Orchid Survey		14.41	
Bank Charges & Interest		11.70	
Depreciation Expense		20.82	
Accounting		200.00	
Treasurer's Expense		225.00	2,238.56
Net Income			
OFNC			1,905.49
CFN			3,569.78
Total Net Income			5,475.27

The Ottawa Field-Naturalists' Club Statement of Profit and Loss — CF-N
for the nine month period ended September 30th, 1977

Revenue			
Income			
Memberships		2,466.87	
Subscriptions		8,496.02	
Grants & Donations			
National Research Council of Canada	3,750.00		
Canadian National Sportsmen's Show	375.00	4,125.00	
Sale of reprints		5,182.00	
Plates & tab settings		1,608.91	
Extra pages & authors' costs		7,380.00	
Sale of back numbers		671.88	
Interest income			
Bank interest	942.52		
Canada Savings Bonds	836.60	1,779.12	31,709.80
Less cost of publications			
Volume 91 (Nos. 1, 2 & 3)		19,616.29	
Reprint costs		2,227.26	21,843.55
Gross profit on operations			9,866.25
Less operating expenses			
Circulation		1,914.78	
Office assistant		1,138.50	
Postage		742.18	
Printing & Stationery		236.32	
Editing — Contracts		660.00	
— General expenses		479.69	
Honoraria		1,125.00	6,296.47
Net Income			3,569.78

Instructions to Contributors

Content

The Canadian Field-Naturalist is a medium for publication of original scientific research papers in all fields of natural history that have relevance to Canada. As the journal has a flexible publication policy, items not covered in the traditional sections (Articles, Notes, Letters, News and Comment, and Book Reviews) can be given a special place provided they are judged suitable. Naturalists are also encouraged to support local natural history publications.

Manuscripts

Please submit, in either English or French, three **complete** manuscripts written in the journal style. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants, or minerals.

Type the manuscript on standard-size paper, if possible use paper with numbered lines, double-space throughout, leave generous margins to allow for copy marking, and number each page. For Articles, provide a running head, a bibliographic strip, an abstract, and a list of key words. These items are optional for Notes. Generally words should not be abbreviated but use SI symbols for units of measure. Underline only words meant to appear in italics. The names of authors of scientific names should be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. Authors are encouraged to use "proper" common names (with initial letters capitalized) as long as each species is identified by its scientific name once.

Although we prefer the names of journals in the Literature Cited to be written out in full, these may be abbreviated following the **Bibliographic Guide For Editors & Authors**, The American Chemical Society, Washington, D.C. (1974). Unpublished reports should not be cited here. Next list the captions for figures (numbered in arabic numerals and typed together on a separate page) and present the tables (each titled, numbered consecutively in arabic numerals, and placed on a separate page). Mark in the margin of the text the places for the figures and tables.

Extensive tabular or other supplementary material not essential to the text, typed neatly and headed by the title of the paper and the author's name and address, should be submitted in duplicate on letter-size paper for the Editor to place in the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Canada K1A 0S2. A notation in the published text should state that the material is available, at a nominal charge, from the Depository.

The **CBE Style Manual**, 3rd edition (1972) published by the American Institute of Biological Sciences, is recommended as a guide to contributors. **Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations—Photographs should have a glossy finish and show sharp contrasts. Photographic reproductions of line drawings, no larger than a standard page, are preferable to large originals. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

Special Charges

Authors must share in the cost of publication by paying $45 for each page in excess of six journal pages, *plus* $5 for each illustration (any size up to a full page), and up to $45 per page for tables (depending on size). Reproduction of color photos is extremely expensive; price quotations may be obtained from the Business Manager. When galley proofs are sent to authors, the journal will solicit on a voluntary basis a commitment, especially if grant or institutional funds are available, to pay $45 per page for all published pages. Authors may also be charged for their changes in proofs.

Limited journal funds are available to help offset publication charges to authors with minimal financial resources. Requests for financial assistance should be made to the Editor when the manuscript is submitted.

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An order form for the purchase of reprints will accompany the galley proofs sent to the authors.

Reviewing Policy of *The Canadian Field-Naturalist*

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it himself or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. The Editor makes the final decision on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality and overall high standards of the journal.

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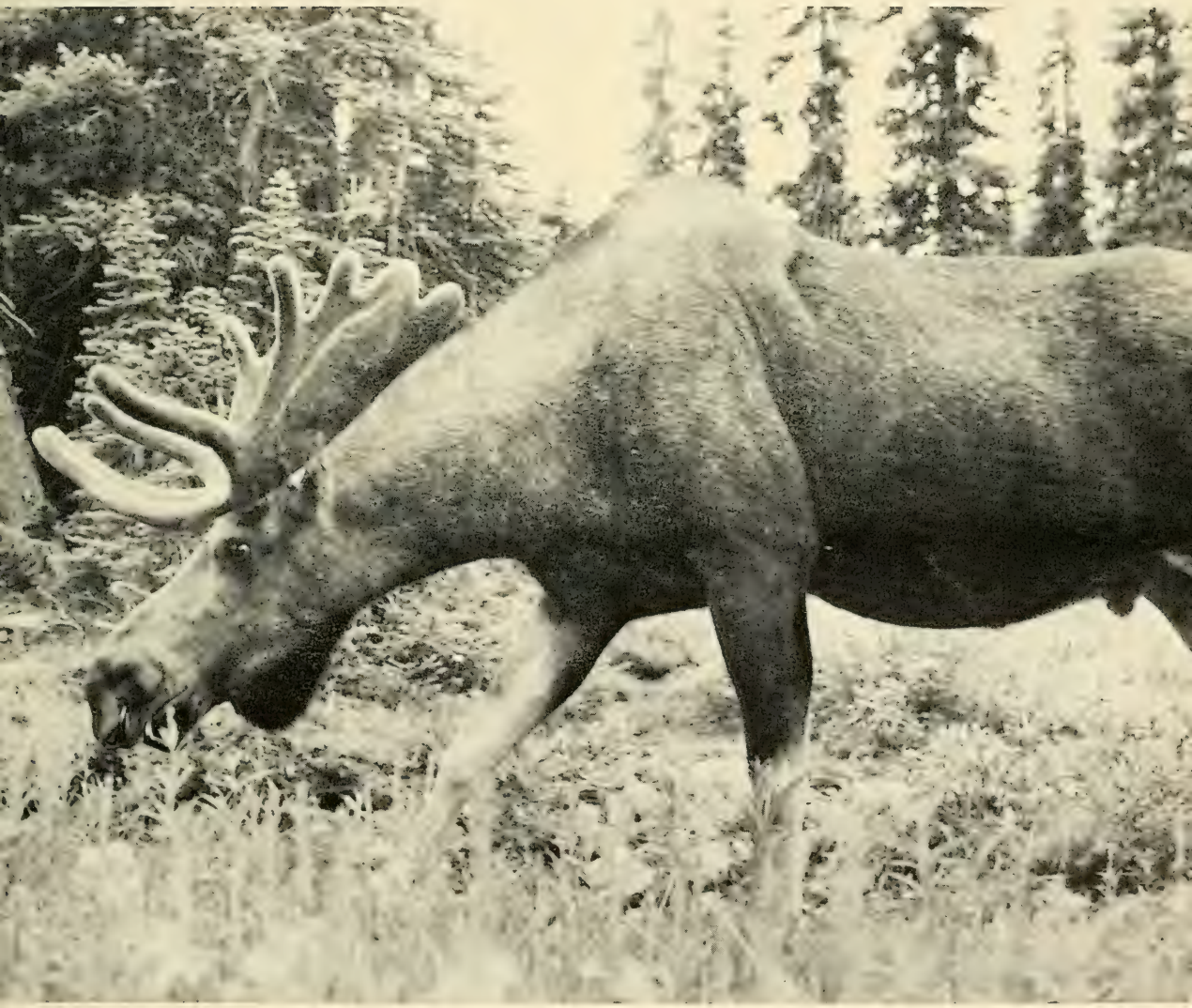

Volume 92, Number 3

July-September 1978

The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

Patrons

Their Excellencies the Governor General and Madame Jules Léger

The objectives of this Club shall be to promote the appreciation, preservation, and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining, or restoring environments of high quality for living things.

The Members of Council are listed on the inside back cover.

The Canadian Field-Naturalist

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Business Manager: Mr. W. J. Cody, Box 3264, Postal Station C, Ottawa, Ontario, Canada K1Y 4J5
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All other material intended for publication should be addressed to the Editor:
Dr. Lorraine C. Smith, R. R. 3, Stittsville, Ontario, Canada K0A 3G0

Urgent telephone calls may be made to the Editor's office (613-996-5840), the office of the Assistant to the Editor (613-231-4304), or their home on evenings and weekends (613-836-1460), or to the Business Manager's office (613-994-9608).

Cover: Moose photographed by Bruno Scherrer in Jasper National Park on 14 August 1975. See articles about Moose on pages 223 and 252.

The Canadian Field-Naturalist

Volume 92, Number 3 July-September 1978

Grouping Characteristics of Moose (*Alces alces*) in Riding Mountain National Park, Manitoba

RICHARD C. ROUNDS

Department of Geography, Brandon University, Brandon, Manitoba R7A 6A9

Rounds, Richard C. 1978. Grouping characteristics of Moose (*Alces alces*) in Riding Mountain National Park, Manitoba. Canadian Field-Naturalist 92(3): 223–227.

Grouping characteristics of the Moose (*Alces alces*) population of Riding Mountain National Park were derived between 1970 and 1974 from 1955 ground sightings involving 3173 Moose, and three aerial surveys. Total population numbers and weather conditions fluctuated considerably, but mean annual group size for all associations remained virtually constant with values ranging from 1.6 to 1.7 animals. Nine of the 12 monthly mean group sizes ranged between 1.5 and 1.7 animals. The November mean of 2.1 Moose per group was the only statistically significant variation observed. Monthly sex-age associations between June and December were analyzed for single male, multiple male, single female, multiple female, female-calf, and mixed-sex groups. A November mean of 2.1 animals per group for all male Moose was the only significant variation observed in sex-age associations. Males were generally more gregarious than females, female-calf groups appeared to be the most stable aggregations, and the overall pattern of grouping behavior appeared to resemble most closely that for herds with approximately equal sex ratios.

Key Words: Moose, grouping behavior, Manitoba, Riding Mountain National Park.

Aggregation in Moose (*Alces alces*) and other ungulates has been attributed to a number of extrinsic and intrinsic factors. Among extrinsic factors commonly postulated are seasonal variation in food availability, weather conditions, vegetative cover, and predator defense (Peek et al. 1974). Intrinsic factors include sex of the animal, reproductive activity, care of young, and herd composition (Tinbergen 1953; Peek et al. 1974).

Data relating to the grouping (aggregation) characteristics of the Riding Mountain National Park Moose herd for the years 1970 through 1974 are presented here. A group is defined to allow for single animals, and the words 'group,' 'association,' and 'aggregation' are used interchangeably. Population changes of the herd, a description of the study area, and air survey methods have already been reported (Rounds 1977).

Methods

From 1970 to 1974, Moose were observed and the sightings recorded on field cards. Sex and age compositions of observed groups were recorded whenever possible and only completely identified groups were used in sex and age categories. Ground sightings used in this report were made by park wardens, professional naturalists, and the author. Structured aerial surveys in February 1974, December 1974, and January 1975 provided comparative information on total mean group size, but were not used to discern group composition except for cow-calf associations.

Biases inherent in non-structured field sightings apply. Available information does not allow delimitation of possible sampling variations from year to year or month to month. These biases should be moderated by the facts that most sightings were made while we were

involved in other activities, the number of personnel reporting sightings did not change significantly, and activities by field staff tended to be seasonal and annually repetitive. The more important potential biases arose from misidentification of age or sex of animals. To avoid as many problems as possible, I used sightings only from the months of June through December for sex-age group delimitations because the January–May period is anterless for males, and consistent adult sex determination was difficult.

Weather Records

Systematic weather records are not available for Riding Mountain National Park. Short-term records for temperature, precipitation, and scattered snow-depth records indicate that temperatures are slightly cooler (2°C), and precipitation 9–17% greater than that at lower-lying nearby settlements (Blood 1966; Bailey 1967). Adjusting precipitation records of nearby stations to the percentage increases noted results in average expected snowfall of 90–100 cm and mean accumulations of 55–60 cm within the park. Mean values of maximum snow accumulations kept at warden stations in various locations within the park during the study period are as follows: 1969 — 31 cm, 1970 — 31 cm, 1972 — 38 cm, 1973 — 36 cm, 1974 — 72 cm, and 1975 — 43 cm (unpublished data from park files). The winter of 1973–1974 gave the only record of snow accumulations above the presumed expected value, with most years considerably below projected mean values.

Results

Grouping Characteristics of Moose

Because overall mean annual and monthly group sizes do not require accurate sex and age determinations, the total 1955 sightings and 3173 Moose reported between 1970 and 1974 provide the data base. The mean annual group size varied only between 1.6 and 1.7 animals (Table 1). This consistent year-to-year group size occurred in spite of the fact that the population changed considerably.

Monthly mean group sizes varied from 1.3 in July to 2.1 in November. Nine of the 12 months varied only between 1.5 and 1.7 Moose per sighting. Analysis of variance indicated that all means were not the same, and subsequent *t*-tests indicated that the mean group size of 2.1 in November was significantly higher than the means for other months ($P \leqslant 0.10$).

Although group composition was not discerned during aerial surveys, the numbers of groups and individuals were recorded. During February 1974, 254 groups containing 336 Moose were recorded. One hundred and seventy-nine of the observations involved single animals (70%) and the mean size for all recorded associations was 1.3 Moose. In December 1974, 146 (59%) of the 246 recorded groups were single Moose, and the total count of 385 resulted in a mean group size of 1.6. The air survey in January 1975 identified 305 groups containing 478 individual Moose. One half of the groups were single Moose, and mean group size was 1.6.

Mean group sizes derived from aerial surveys approximate those of ground observations. Ground observations during February indicate a mean value of 1.6 Moose per group over the five years of record. Reports for February 1974, however, indicated a mean group size of 1.4 animals, which is nearly identical with the 1.3 animals recorded during the air survey. Values of 1.6 Moose per group for the December 1974 and January 1975 surveys correspond with the long-term ground observation means for the two months.

TABLE 1—Moose herd characteristics from ground observations and aerial survey population estimates

		All moose		
Year	Population estimate	No. reports	No. reported	Mean group size
1970	—	307	520	1.7
1971	2448	302	516	1.7
1972	—	457	736	1.6
1973	1896	365	571	1.6
1974	1348	524	830	1.6
Total/Mean		1955	3173	1.6

TABLE 2—Monthly size and composition of adult male and adult female Moose groups, from ground observations, 1969–1974

Month	Single bulls	Multiple bulls			All bulls			Single cows	Multiple cows			All cows		
		No. groups	No. bulls	Mean group	No. groups	No. bulls	Mean group		No. groups	No. cows	Mean group	No. groups	No. cows	Mean group
June	21	3	6	2.0	24	27	1.1	17	1	3	3.0	18	20	1.1
July	19	2	5	2.5	21	24	1.1	25	5	11	2.2	30	36	1.2
Aug.	23	5	10	2.0	28	33	1.2	22	4	8	2.0	26	30	1.2
Sept.	38	13	27	2.1	51	65	1.3	33	9	20	2.2	42	53	1.3
Oct.	79	19	45	2.4	98	124	1.3	64	12	27	2.3	76	91	1.2
Nov.	21	28	84	3.0	49	105	2.1	30	14	36	2.6	44	66	1.5
Dec.	46	19	52	2.7	65	98	1.5	72	15	34	2.3	87	106	1.2

Adult Male and Adult Female Groups

Sighting of single adult males occurred in all months, but early fall reports were most frequent (Table 2). The greatest number of observations of lone bulls occurred in October (the breeding season), while they constituted the lowest percentage of groups in November, after the rut. Groups containing more than one adult male are also reported in all months with the largest mean group size (3.0) reported during November, the same month that the mean size for all bull groups reached a peak (Table 2). The mean of 2.1 for all bull groups in November is significantly higher than the means for other months ($P \leqslant 0.10$).

Reports of single adult females were much more common than multiple female groups. Associations containing more than one adult female averaged 2.3 individuals. Single-cow sightings were noticeably less frequent during the post-breeding period (November), when multiple-cow associations reached maximum size (Table 2). There are no significant differences among the mean group sizes for either multiple or all cow groups ($P \geqslant 0.10$).

Female-young and Mixed-sex Groups

Associations containing adult females with calves were reported in all months, but sightings were rare in June and July when calves were small (Table 3). Cows with single calves were reported in 89% (N = 169) and cows with two calves in 11% (N = 20) of the calf-cow groups. The mean size for all cow-calf groups does not vary significantly throughout the 7-month period (Table 3). Unaccompanied calves were reported only 19 times in all months during the 5-yr period.

Mixed-sex associations were reported in all months, but were most common during the rut and post-rut period (September–November) (Table 3). Bull-cow groups were more common, formed a month earlier, and lasted a month longer than bull-cow-calf groups. It would appear that cows with calves remain with adult males only long enough to breed. Mean group size for both associations indicates that more than one female or male was present with the opposite sex on many occasions (the presence of two calves with some females may skew the

TABLE 3—Monthly size and composition of female-young and mixed-sex Moose groups, from ground observations, 1969–1974

Month	No. cows with one calf	No. cows with two calves	All cow-calf groups			Bull-cow groups			Bull-cow-calf groups			All mixed groups		
			No. groups	No. animals	Mean group	No. groups	No. animals	Mean group	No. groups	No. animals	Mean group	No. groups	No. animals	Mean group
June	12	4	16	36	2.3	—	—	—	2	8	4.0	2	8	4.0
July	8	1	9	19	2.1	4	9	2.3	1	3	3.0	5	12	2.4
Aug.	17	1	18	37	2.1	7	17	2.4	2	9	4.5	9	26	2.9
Sept.	36	4	40	84	2.1	28	68	2.4	5	16	3.2	33	84	2.6
Oct.	35	4	39	82	2.1	26	63	2.4	20	87	4.4	46	150	3.3
Nov.	33	4	37	78	2.1	18	57	3.2	5	22	4.4	23	79	3.4
Dec.	28	2	30	62	2.1	13	36	2.8	10	43	4.3	23	80	3.4

group size for bull-cow-calf associations). Mixed-sex groups are not common during June, July, and August when the cows are giving birth or suckling new-born calves. There are no significant differences ($P \leqslant 0.10$) among group sizes of any of the mixed-sex associations.

Discussion

The annual grouping characteristics of all Moose were nearly constant (Table 1) despite population change and considerable variation in winter conditions (Rounds 1976, unpublished report, Parks Canada). Aggregations were generally smaller in summer and larger in winter, but monthly deviations from the total mean of 1.6 animals were not great except for the November post-rut period. Similar trends in aggregations have been reported for Moose in northeastern Minnesota, Kenai, Alaska, and southwestern Montana (Peek et al. 1974).

Peek et al. (1974) postulated that bull Moose are more gregarious than cows, but that herd sex ratio has an effect on the aggregation of all Moose. In Minnesota and Montana, where sex ratios approached equality, the males showed greatest tendency to aggregate in fall and early winter. In Montana, secondary grouping with great variability was noted in May–June. In Alaska, with a sex ratio of 20 males per 100 females, the Kenai Moose population showed largest male groups in the summer with secondary peaks in November and March. Bull Moose in Riding Mountain most closely reflect the grouping behavior of herds with nearly equal sex ratios, as low summer aggregation, followed by marked rut and post-rut increases in group size, most closely parallels that of the Minnesota and Montana herds.

Cow Moose without calves do not aggregate to any great extent, as mean monthly group sizes varied only between 1.1 and 1.3 animals, with the exception of a post-rut peak of 1.5 in November (Table 2). This pattern closely parallels that observed in Minnesota and Montana (Peek et al. 1974). Single cows were reported four times more frequently than multiple cow groups, reflecting the less gregarious nature of females.

Adult females with calves are aggressive and generally avoid groupings with all other Moose except males during the rut (Geist 1963). The cow-calf group, however, is perhaps the only prolonged association characteristic of Moose. The monthly variation in cow-calf group size from 2.1 to 2.3 (Table 3) illustrates the consistency of these groups, and is in accord with most other studies (Altmann 1958; de Vos et al. 1967; Peek et al. 1974).

Mixed-sex groups were reported in all months, but were most numerous during the pre-rut, rut, and post-rut periods (September–December) (Table 3). Mixed aggregations without calves were reported twice as often as those with calves. A wide range in mixed-sex group size was evident from field observations. Aggregations during pre-rut and post-rut periods larger than during the rut have been reported (Altmann 1959), but evidence from Riding Mountain does not support this observation. The tendency for cows with calves to avoid other aggregations remains consistent in that prolonged contact with breeding males is not maintained.

In total, the pattern of mean monthly group sizes is most affected by changes in bull and mixed-sex aggregations. The post-rut peak in association is most closely related to gregariousness among males and the presence of significant numbers of mixed groups. Cow-only and cow-calf groups are apparently very stable, although cow-only groups were slightly larger in November. The summer decrease in mean group size is affected by both the solitary nature of bulls during this period and the absence of mixed-sex groups.

Weather conditions, vegetative cover, and associated seasonal variation in food supply have been proposed as factors affecting Moose grouping behavior (Edwards and Ritcey 1958; Knowlton 1960; Stevens 1970; Peek 1971). In mountainous terrain, heavy snows often force vertical migration of Moose to low-lying ranges, thereby concentrating the population and increasing behavioral interaction. Although seasonal shifts are evident in Riding Mountain, the relief is not sufficient to allow avoidance of extreme winter conditions; Moose do not concentrate heavily in few areas, and subsequent effects on grouping behavior are not evident.

Houston (1968) and Geist (1971) suggest that dispersal in a Moose population facilitates utilization of sparse forage sources. The Moose

of Riding Mountain are widespread within the park and occupy nearly every recognized cover vegetation. The generally rolling terrain and ubiquity of usable forage, therefore, appear to be more conducive to dispersal than to aggregation. The fact that mean annual group size did not vary (Table 1) with changes in both total population and widely different winter conditions (as measured by snow-depth) between 1970 and 1974 suggests that density, weather, and food availability have little effect on aggregation in this area.

An advantage to dispersal may be protection from predation. The study area has a sizable Timber Wolf (*Canis lupus*) population which may affect Moose behavior. Whatever effect might occur, however, would be tempered by the availability of alternative prey (Carbyn 1974) in that Wapiti (*Cervus elaphus*) and White-tailed Deer (*Odocoileus virginianus*) are common in the region.

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Regional Movements and Mortality of Great Horned Owls in Relation to Snowshoe Hare Fluctuations

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Adamcik, R. S. and L. B. Keith. 1978. Regional movements and mortality of Great Horned Owls in relation to Snowshoe Hare fluctuations. Canadian Field-Naturalist 92(3): 228-234.

Banding summaries and recoveries for Great Horned Owls (*Bubo virginianus*) from wooded regions of the Canadian Prairie Provinces were analyzed according to years of population increase and decline. Fifty-three percent of 158 individuals banded as nestlings were recovered within 25 km of their banding sites; the remaining recoveries were widely distributed over distances up to 1305 km. Movements ≤25 km were arbitrarily classified as "non-dispersal," and those >25 km as "dispersal." Accordingly, 64% of recoveries during years of owl population decline were from individuals that had dispersed, but only 28% had dispersed during increase years. Mean dispersal distance was also significantly greater during decline years (443 vs. 323 km). Only 10% of all horned owls recovered during years of population increase had moved > 100 km; 48% moved > 100 km during years of decline. Direction of dispersal was largely independent on the population trend. Life-table analyses gave mean estimates of age-specific mortality since 1955 of 55, 39, and 22% during first, second, and later years, respectively. Mortality rates did not change between years of owl population increase and decline. Fluctuations in Snowshoe Hare *(Lepus americanus)* abundance appear to cause significant increases in horned owl movements, but not in mortality. This contrasts with the situation in some European raptors where high mortality allegedly occurs among juveniles during their emigrations following declines in small-mammal populations. Horned owls cease breeding early in the more extended Snowshoe Hare declines, and thus few juveniles are present during hare lows.

Key Words: Great Horned Owl, Snowshoe Hare, 10-year cycle, population fluctuations, dispersal, mortality.

Recent studies near Rochester, Alberta, have shown that Great Horned Owls *(Bubo virginianus)* exhibit strong functional and numerical responses to the cyclic fluctuations of Snowshoe Hares *(Lepus americanus)* (Rusch et al. 1972; McInvaille and Keith 1974; Keith et al. 1977). Annual changes in numbers of resident pairs of owls on the Rochester study area were found to be importantly influenced by ingress and egress (Adamcik et al. 1978). We thus decided to conduct an analysis of regional banding records from the three Canadian Prairie Provinces to examine effects of hare fluctuations on horned owl movements and mortality over a large geographic area. Our general hypothesis was that there have been major differences in annual movements and post-fledging mortality of Great Horned Owls, which were related to the status of Snowshoe Hare populations.

The terms "boreal forest" and "boreal forest ecosystem" are applied broadly in the present paper to that complex of northern plant communities, with or without conifers, in which Snowshoe Hares are found. We emphasize this point because there are many thousands of square miles of forest and woods between the Precambrian Shield and the Rocky Mountains that are dominated by Trembling Aspen *(Populus tremuloides)*, Balsam Poplar *(Populus balsamifera)*, and Paper Birch *(Betula papyrifera)*; and it is such deciduous stands that comprise the best habitat for Snowshoe Hares in western Canada.

Methods

Banding Data for Movement and Mortality Calculations

A summary of all Great Horned Owl bandings and recoveries for Alberta, Saskatchewan, and Manitoba was obtained from the United States Fish and Wildlife Service, Office of Migratory Bird Management, Laurel, Maryland. Records of birds banded outside the Boreal Forest and Aspen Parkland zones of these provinces (non-habitat for Snowshoe Hares) were deleted. This excluded region is largely open farmland and Mixed Prairie lying south of 52°10′N (approximately through the cities of Red Deer and Saskatoon), west of 105°20′W, and southwest of a diagonal with ends at 51°N, 105°20′W and 49°N, 103°W.

The final data set consisted of 158 recoveries of birds banded as nestlings since 1950, and 2163 banding records since 1955 (banding records

before 1955 were not accessible). The total recovery rate since 1955 was 7.2%. The majority of bandings and recoveries were from Saskatchewan (1823 and 131), followed by Alberta (333 and 27) and Manitoba (7 and 0).

Determination of Population Trends and Peak Years

Numerical trends and peak years among Snowshoe Hares and Great Horned Owls were estimated from provincial fur returns for Lynx *(Felis lynx)*. Our approach was to use cyclic peaks in the fur-harvest data as reference points for estimating peak hare populations since 1950.

The hare peaks that occurred at Rochester, Alberta, in the falls of 1961 and 1970 (Keith and Windberg 1978) were in the first case concurrent with, and in the second 1 yr prior to, the peaks in province-wide fur returns for Lynx during the winters of 1961–62 and 1971–72. That regional hare peaks occurred in Alberta during 1970 and 1971 was also established by an annual questionnaire, started in 1964, to registered trappers. Information summarized earlier by Keith (1963) suggested that regional hare populations have tended to peak with, or 1 to 2 yr before, peaks in Lynx fur returns. We thus assumed in the present analysis that hare numbers were highest 1 yr before Lynx fur peaks.

Maxima in horned owl populations were also estimated from Lynx fur peaks. Actual field data on their chronological relationship were limited to (1) our observation at Rochester that the owl population remained at its maximum for 1 yr after the peak in Lynx fur returns (2 yr after the hare peak in fall 1970), and (2) Houston's (1971, 1975) banding records and observations which indicated horned owl peaks in Saskatchewan during 1960, and 1970 or 1971—1 or 2 yr after the Lynx fur peaks there. We thus designated the cyclic highs of horned owls since 1950 as occurring 1 yr after the peaks in Lynx fur returns for Alberta, Saskatchewan, and Manitoba (Table 1).

Because these cyclic fluctuations were not entirely synchronous over the three provinces, the owl banding records for each were first segregated according to number of years before or after peaks. The data were then pooled to create two blocks of years. The first block ("increasing") consisted of peak years for owls plus the 3 yr immediately preceding. According to our Rochester studies, all years in this grouping should be characterized by 100% nesting among resident pairs of horned owls (McInvaille and Keith 1974; Adamcik et al. 1978). The second block ("decreasing") comprised the 3 yr immediately post-peak. We compared dispersal and mortality between these blocks of years.

TABLE 1—Peaks in Great Horned Owl populations, as estimated from known peaks in Lynx fur returns. See text for discussion of relationship between these peaks

Province	Peak years[1]	
	Lynx[2]	Horned Owl
Alberta	1952	1953
	1961	1962
	1971	1972
Saskatchewan	1952	1953
	1959	1960
	1969	1970
Manitoba	1952	1953
	1959	1960
	1971	1972

[1]Biological year beginning 1 June.

[2]As determined from fur returns obtained from annual reports of the Alberta Department of Lands and Forests, the Manitoba Department of Mines and Natural Resources, and the Saskatchewan Department of Tourism and Renewable Resources.

Calculation of Recovery Distances

In data obtained from the banding office, the location of each banding and recovery record is defined by the 10-min rectangular area of latitude and longitude in which the record occurs. The coordinates used in coding location are those of the rectangle's southeast corner. Recovery distance was that distance between the banding and recovery coordinates. This approach produces an inherent error, since a bird could conceivably move diagonally within the 10-min rectangle in which it was banded (a maximum distance of approximately 22 km) and still be recorded as having made no movement. Conversely, an individual could move a short distance into an adjacent rectangle and thus be recorded as recovered in its southeast corner (a distance of 7 to 22 km). This error is quickly reduced as recovery distance increases. All movements of $\leqslant$ 25 km were grouped into a single category in our analysis to minimize such errors.

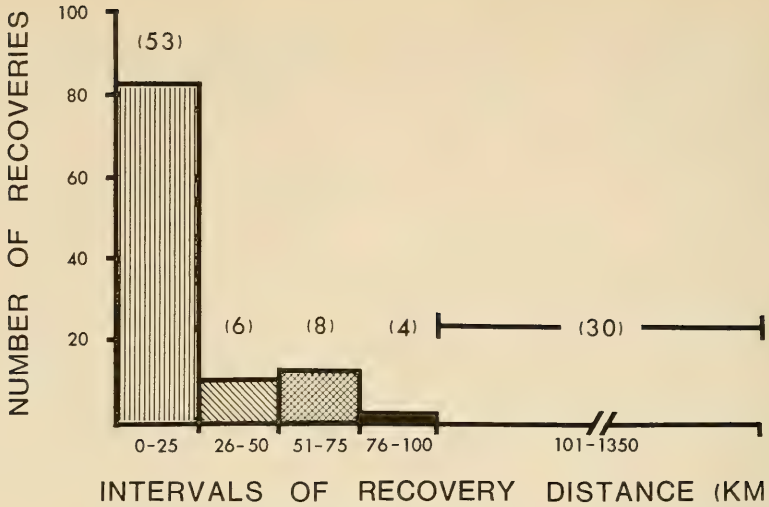

FIGURE 1. Frequency histogram illustrating the pattern of recovery distances of 158 Great Horned Owls banded as nestlings. Figures in parentheses are percentage of total recoveries within the interval.

Results

Dispersal

To gain an overview of horned owl movements in the north, we first examined the general pattern of band recoveries. Of 158 recoveries of birds banded as nestlings, 84 (53%) occurred within 25 km of the banding site. A frequency histogram of recovery distances (Figure 1) exhibited a sharp decline after 25 km, with the remaining recoveries spread over intervals of up to 1305 km. We thus arbitrarily defined all movements $\leqslant 25$ km as "non-dispersal" and those > 25 km as "dispersal."

The proportion of banded owls recovered at distances > 25 km was highest ($P < 0.05$) within the block of years of population decline (64 vs. 28%). This difference in apparent dispersal (Table 2) was also significant when annual recoveries within the 3-yr decreasing block were segregated and tested individually against years of population increase.

Dispersal distances within each block of years were subjected to a log-transformation to approximate a normal distribution before testing the difference between their means. The mean distance at which dispersing owls were recovered was greater ($P < 0.05$) within the decreasing-year block (443 km) than during increasing years (323 km). The patterns of dispersal were also different: recoveries during years of increasing population were mainly (90%) within 100 km of the banding site, but five of the seven birds that exceeded this distance had moved beyond 700 km. Recoveries during declining years, on the other hand, were more continuously distributed, with only 51% at less than 100 km (Table 3).

The assessment of directional tendencies in

TABLE 2—Comparison of dispersal among Great Horned Owls during 4 consecutive years of population increase and 3 consecutive years of decline. Total band recoveries each year are shown in parentheses. All birds banded as nestlings

	Population increase or decline years				
	1	2	3	4	Mean
% dispersing in years of population increase	25(12)	18(11)	37(19)	28(32)	28
% dispersing in years of population decline	58(24)	62(29)	77(13)	——	64

TABLE 3—Distribution of recovery distances of Great Horned Owls during 4 yr of population increase and 3 yr of decline. All birds banded as nestlings

	Recovery distances (km)			
	0–25	26–99	100–299	300–1350
% of 74 recoveries in increase years	72	18	3	7
% of 66 recoveries in decline years	36	15	18	30

dispersal (> 25 km) was complicated by denser human populations and hence increased probability of band recovery to the south. We therefore compared the proportion of recoveries which were north and south, and then east and west, of banding locations during years of population increase vs. decline. These proportions were not statistically different: 67% of recoveries were to the south during increase years vs. 69% during decline years; 67% were to the east during increase years vs. 76% during decline years. We thus concluded that the direction of dispersal was largely independent of population trend.

Houston (1978) analyzed 209 returns from his own bandings in Saskatchewan. Eighty-seven recoveries at 10 to 250 km from banding sites showed no apparent directionality, but 35 of 36 recovered beyond 250 km had moved southeast (31 of the 35 during population declines). The above analyses and earlier field observations (Swenk 1937; Speirs 1939) led Adamcik et al. (1978) to speculate that "...dispersal among the vast majority of horned owls is essentially random in all years, but ... during periods of population decline there is a cohort which does move well to the south and hence out of the Boreal Forest ecosystem. The fact that none of Houston's owls which had moved over 250 km southeast were recovered during May-August suggests that even these long-range dispersers probably return north in spring and summer...."

Mortality

We used life-table analyses of band returns to estimate average annual mortality rates of northern horned owls, and also compared rates in years of increasing and decreasing population. Birds were considered to be entering their second year of life on 1 June of the first calendar year after banding; only individuals banded as nestlings were utilized in this analysis.

Band returns could be broadly classified as coming from two sources: (1) shot and trapped birds, and (2) birds found dead. Although the second source is probably not wholly independent of the first, it seems reasonable to assume that it more closely approximates a sample of natural mortalities. The key piece of information provided here by band returns is age at death (d_x data); to obtain an unbiased estimate of age-specific mortality from a composite dynamic life table this sample of band returns must be representative of age at death for the population as a whole.

Earlier studies on a variety of birds have shown that shot and trapped samples tend to contain a disproportionate number of young individuals (Lack 1943; Hickey 1952; Haukioja and Haukioja 1970), and thus yield overestimates of early mortality when used as a sample of the living (l_x data) in a composite life-table analysis. This bias, would, of course, not occur, or would be minimal, where mortality from shooting and trapping constituted all or an overwhelming proportion of total mortality, i.e., where the data could be considered as d_x rather than l_x in nature. There is, however, no evidence that this was the case among horned owls, since reported first-year losses to guns and traps amounted to only 1.6% of bandings compared to estimated total first-year mortality of 55% as discussed later. Although some shot and trapped birds which carried bands were doubtless not reported, the difference between the foregoing rates is so great that we can safely conclude that hunting and trapping accounted for only a small fraction of total annual mortality.

As a result of the above consideration, we decided to utilize only recoveries in the "found-dead" category as d_x data. Recoveries of "shot

TABLE 4—Summarized life-table data, and calculated age-specific mortality among Great Horned Owls banded as nestlings in forest and parkland regions of Alberta, Saskatchewan, and Manitoba during 1955–1973

Age interval (yr)	Banded owls available for recovery	Recoveries other than from shooting and trapping (d_x data)		Calculated mortality rate	Recoveries from shooting and trapping (l_x data)		Calculated mortality rate	Mean estimate of mortality rate
		Number	Percent		Number	Percent		
0–1	2163	61	2.82	0.58	34	1.57	0.52	0.55
1–2	2123	12	.57	0.28	16	.75	.49	0.39
2–3	1845	7	.38		7	.38		
3–4	1608	6	.37		2	.12		
4–5	1279	2	.16	0.26	1	.08	0.18	0.22
5–6	981	1	.10		2	.20		
6–7	669	1	.15		1	.15		
Older[1]		1	.29		1	.35		
Totals and means		91		0.39	64		0.44	0.41

[1]The two older recoveries occurred at age intervals 11–12 and 13–14 yr.

and trapped" birds were analyzed as l_x data with the expectation that the resulting estimate of first-year mortality would be biased upward, and thus higher than that from the analysis of "found-dead" recoveries (Table 4). This proved not to be the case, suggesting that the "shot and trapped" sample did not contain a disproportionate number of young individuals, or that both samples were similarly biased. Since we could not resolve this problem further, the results of each analysis are given here. Lacking information on annual variation in the probability of recovering banded owls, we assumed that this fluctuated randomly and that potential errors in age-specific mortality estimates were thus self-cancelling over the 20-yr span of data.

Overall mortality since 1955, as estimated from 91 "found-dead" recoveries (d_x) corrected for incomplete cohorts (Haldane 1955), was 58% in the first year of life, 28% in the second, and 26% annually thereafter (Table 4). Estimates for the same age classes from 64 shot-and-trapped recoveries (l_x) were 52, 49, and 18%. In view of the similarity of calculated first-year mortality rates, and because of small sample sizes, we feel that the best estimates of average annual mortality among the three age classes are probably given by the mean values of 55, 39, and 22% (Table 4). These are close to the average first-, second-, and later-year mortality rates of 50, 40, and 29% calculated by us from 288 recoveries of horned owls banded and recovered continentally through 1965–66, as summarized from Stewart (1969) and Henny (1972). Estimates of first-year mortality for both Boreal Forest and Continental North American horned owl populations differed significantly ($P < 0.02$) from average annual mortality among older age classes when tested by chi-square using the method of Robson and Chapman (1961).

Recoveries from nestling banding were partitioned into years of increasing and peak populations vs. years of decline. Only recoveries in the found-dead category were utilized because of the small samples available, and even here the 43 and 36 recoveries during increase and decline years, respectively, were barely adequate for mortality estimates (Table 5). Our conclusion of no significant difference in mortality between these two year groups must therefore be considered tentative. Calculated mean annual mortality of all age classes was 41% during the owl population increase and 38% during the decline.

Discussion

The large proportion (53%) of recoveries within 25 km of banding (nest) sites indicates that horned owls in the Boreal Forest of Western Canada usually disperse only short distances. This conclusion is consistent with that of Stewart (1969) for the species in general. Northern horned owl populations have long been thought to fluctuate markedly (Speirs 1939), and our recent 10-yr study at Rochester confirmed this (Adamcik et al. 1978). The present analysis suggests that movements differ

TABLE 5—Summarized life-table data, and calculated age-specific mortality among Great Horned Owls banded as nestlings in forest and parkland regions of Alberta, Saskatchewan, and Manitoba during 1955–1973. All recoveries are from other than shooting and trapping. Estimates of mortality are separated into years of owl population increase and peak vs. decline

Age interval (yr)	Banded owls available for recovery during years of population increase and peak	Recoveries (d_x data)		Calculated mortality rate	Banded owls available for recovery during yrs of population decline	Recoveries (d_x data)		Calculated mortality rate
		Number	Percent			Number	Percent	
0–1	1508	32	2.12	0.54	468	18	3.85	0.64
1–2	1047	7	0.67		972	5	0.51	
2–3	648	2	0.31		1210	5	0.41	
3–4	369	1	0.27		1336	5	0.37	
4–5		0		0.33		0		0.22
5–6		0			614	1	0.16	
6–7	173	1	0.58		301	1	0.33	
Older[1]		0			233	1	0.43	
Totals and means		43		0.41		36		0.38

[1]The single older recovery occurred at age interval 11–12 yr

between increase and decline phases of these fluctuations.

A number of boreal raptors are noted for mass movements. The Hawk Owl *(Surnia ulula)* and Great Gray Owl *(Strix nebulosa)* are examples from Europe (Honer 1963; Hagen 1956; Höglund and Lansgren 1968); the Great Horned Owl, Snowy Owl *(Nyctea scandiaca)*, and Goshawk *(Accipiter gentilis)* are examples from North America (Speirs 1939; Gross 1947; Lack 1954, p. 209). All tend to be restricted feeders, especially in winter months, and Lack (1954, p. 209) felt that real or impending food shortage triggered their emigrations.

The highly specialized feeding of Great Horned Owls was seen at Rochester where Snowshoe Hares comprised at least 90% of the winter diet during 3 successive years of hare decline. In the fourth winter, when hares were at their cyclic low, they still comprised 50% of the owls' diet (Adamcik et al. 1978).

The periodic mass movements of northern horned owls have been attributed to Snowshoe Hare declines (Lack 1954, p. 209), and data presented in this paper suggest increased egress during periods of low and decreasing hare density. Only 10% of horned owl movements exceeded 100 km during years of population growth when hares were abundant; but during years of hare scarcity and consequent owl population decline, almost 50% moved more than 100 km. We have calculated (Adamcik et al. 1978) that there was a net egress of horned owls annually from the Rochester study area during 1972–1975 when hare populations were declining and low. Such losses were equivalent to between 9 and 62% of the remaining population of territorial birds each year.

Movements of horned owls were directionally similar for a large proportion of the population during egress and non-egress years. Thus increased dispersal appears mainly to be an amplification of usual fall movements, as suggested by Svardson (1957) for invasions of non-raptorial species.

Great Horned Owl Movements and Mortality

That mortality probably did not increase in declining horned owl populations supports Lack's (1954, p. 209) view that emigration occurs before overwinter food shortage becomes critical. This contrasts with the so called "mortality outbursts" or "starvation migrations" of some European raptors (Honer 1963; Höglund and Lansgren 1968). Emigrating Barn Owls and Great Gray Owls, for example, are often found emaciated or starved. The microtine prey of these raptors undergo mainly 3- to 5-yr cycles of abundance, and support raptor reproduction for 1 or perhaps 2 yr. The usual rapid decline of this prey base affects largely inexperienced juveniles which allegedly starve while wandering in search

of food (Honer 1963). The decline among Snowshoe Hare populations, on the other hand, may take 4 to 5 yr. Breeding activity among horned owls stops early in the decline (Adamcik et al., 1978), and hence there are fewer juveniles, and fewer individuals in general, to compete for a diminishing food source.

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Alaskan Distribution of the Beluga Whale, *Delphinapterus leucas*

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Results of observations of Beluga Whales from 80 000 km of aerial survey trackline in Alaska indicate an apparent absence of this species in many coastal and most offshore waters. Important populations are located in the Gulf of Alaska, especially the Cook Inlet, northern Bristol Bay, Norton Sound, and a northern migratory one which winters in the Bering Sea and summers in the eastern Beaufort Sea. Beluga occur regularly in deep water offshore during summer in the Beaufort Sea and can occur offshore elsewhere, but are predominantly coastal in the Bering Sea and the Gulf of Alaska. We suspect that there are no major populations of this species unreported in Alaskan waters.

Key Words: Beluga Whale, *Delphinapterus leucas*, White Whale, Odontoceti, Odontidae, Alaskan cetacea, aerial survey, marine mammal.

Beluga Whales (*Delphinapterus leucas*) are distributed throughout the arctic and subarctic regions of North America, Europe, and Asia. Vladykov (1944) prepared a chart which shows that nearly all major concentrations occur in shallow bays or estuaries of large rivers north of 40°N. They can inhabit ice but are limited by an inability to make breathing holes in any but the thinnest ice (Fay 1974). Papers describing the recent status of this species have been published for the USSR (Kleinenberg et al. 1964), Northern Europe (Nazarenko 1965), and North America with emphasis on Canada (Sergeant and Brodie 1975). Published work on the distribution of Beluga in Alaska have been limited to incidental observations and general comments (for example, Bailey and Hendee 1926; Johnson et al. 1966; Fay 1974). This paper reports the results of Beluga Whale observations from a systematic, Alaska-wide aerial survey program including observations from both winter and summer months.

Methods

Aerial surveys designed to establish the seasonal distribution and abundance of marine mammals and birds were flown periodically over Alaskan coastal and outer continental-shelf waters and ice from 1975 to 1977 and totalled approximately 80 000 km of trackline. Survey aircraft were a modified Grumann turbo-goose with improved forward and lateral visibility, and a Lockheed Neptune P2V with a bow plexiglass observation bubble. These were flown on surveys at an altitude of 30 m and a groundspeed of 200 km/h. The aircraft were equipped with a Global VLF Navigation System (Karant 1976), which utilizes the very low-frequency radio band and provides a continuous readout of longitude and latitude. Two biologists acted as observers, one for each side of the airplane, and a third utilized a cassette recorder to record periodic geographical positions and observations of marine mammals and birds. Approximately every 30 min the biologists switched seating arrangements to combat observer fatigue and to allow one of the three to ease his eyestrain by diverting his attention to the Global VLF. A 100-m transect width was used for birds, but all Beluga were recorded, regardless of distance from the aircraft. Supplementary data recorded for all surveys were sea state, wind, ceiling, ice conditions, and presence of calves. Except for portions of northern Cook Inlet, the waters surveyed were clear and free from turbidity.

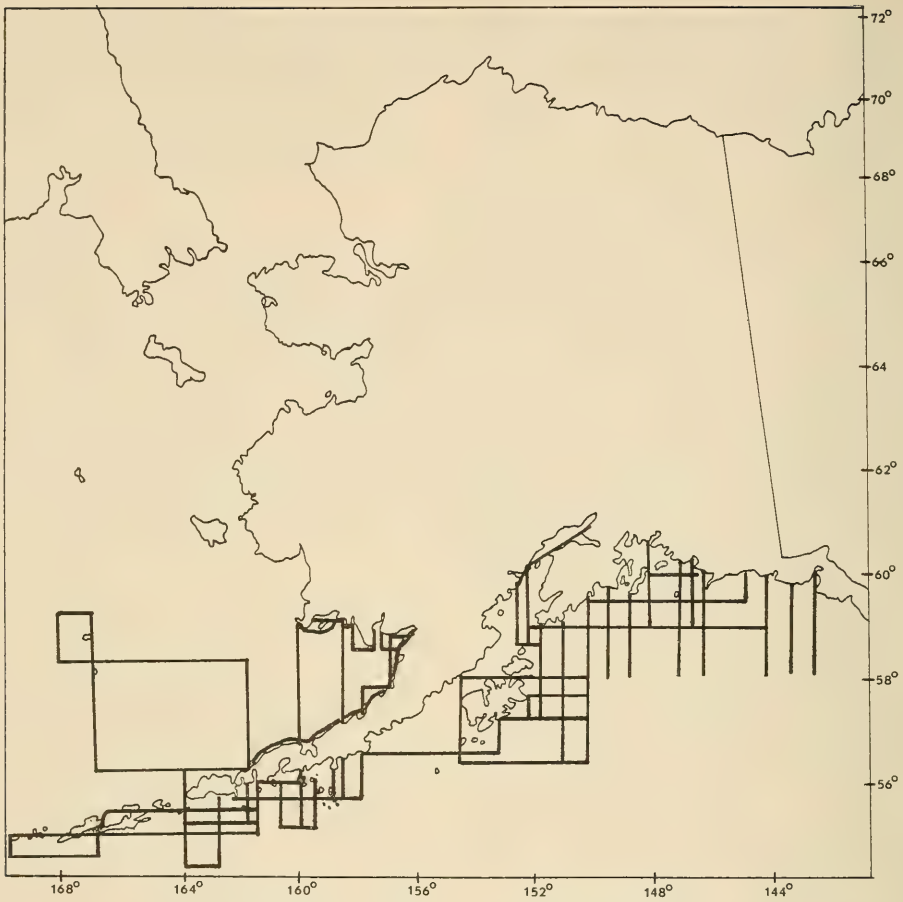

FIGURE 1. Aerial survey tracklines, November–April 1975–1977.

Results and Discussion

Figures 1 and 3 show aerial tracklines flown during the winter (November–April) and summer (May–October) months, respectively. Figures 2 and 4 depict Beluga sightings for corresponding time periods. Most tracklines in Figures 1 and 3 were covered more than once during each 6-mo period; consequently these illustrations portray minimum survey range and intensity for each half-year. Specific months during which surveys were conducted are discussed below. Table 1 lists chronologically all Beluga sightings for these surveys and includes relevant environmental data. We observed 99 animals on 29 occasions for a mean 3.5 animals/observation. In no instance did we encounter large groups of hundreds or thousands such as those reported in Hudson Bay or the Mackenzie Delta, Canada (Sergeant and Brodie 1975). Our relatively low mean herd size is probably a result of the fact that we may not have censused prime migratory routes during migration, nor did we survey calving grounds. Further, Beluga apparently are not as numerous in Alaska as in Canada (Sergeant and Hoek 1974). Numbers of observed Beluga are minimum estimates since Cetacea spend considerable time at depths which do not allow visual detection; nevertheless patterns of geographical and habitat usage emerge from these surveys.

Western Beaufort Sea

Surveys in this region were conducted during July and August and the region contained 6000 km of trackline. Beluga pass through these

FIGURE 2. Beluga Whale sightings, November–April 1975–1977.

waters in migration from the Bering Sea each spring en route to feeding grounds near Banks Island and calving grounds in the Mackenzie Delta (Sergeant and Hoek 1974). They arrive in Canadian waters between May and July (Fraker 1977) and have been recorded at Point Barrow in early May (McVay 1973). We had two sightings each month in July and August for a total of 35 animals. All sightings occurred approximately 100 km offshore, in water depths of 1800 m, and in polynya. Distance offshore and water depths of Beluga in the Beaufort Sea contrast sharply with sightings from the remainder of Alaska in which Beluga are found a mean 15 km offshore and at a mean water depth of 26 m. Therefore our data indicate that summer Beluga in the western Beaufort Sea are found in offshore leads in contrast to the more general situation in which Alaskan Beluga utilize estuaries, shallow coastal bays, and sounds. The cow and calf (calf 40% length of adult) that were sighted in late August may indicate an early movement away from calving grounds in the Mackenzie Delta and possible offshore nursing for young-of-the-year.

Chukchi Sea

Surveys of 7000 km of trackline in the Chukchi Sea were completed in June, August, and October. Beluga have been observed in the Bering Strait area during February and March (Kleinenberg et al. 1964) and northward migration has been documented at Point Hope in April (Johnson et al. 1966). Animals have been sighted in an estuary north of Cape Lisburne in June (Childs 1969) and southward migration has been noted at Point Barrow in

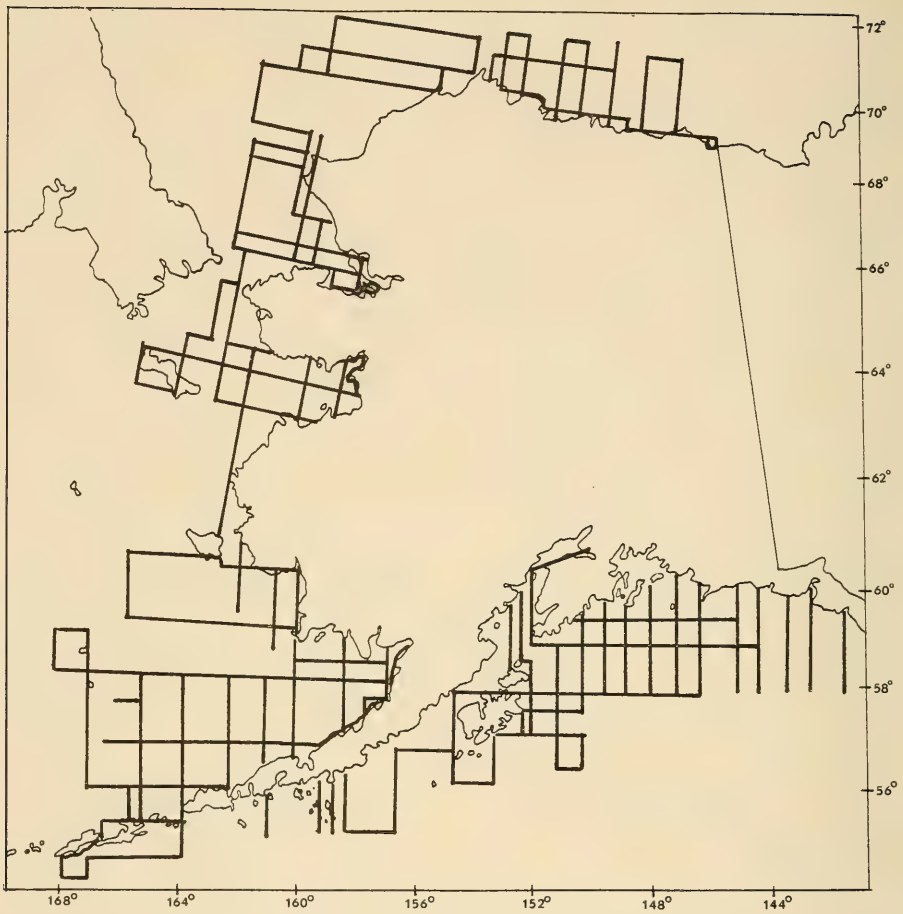

FIGURE 3. Aerial survey tracklines, May–October 1975–1977.

October (Bailey and Hendee 1926). Recently, Beluga have been sighted in Eschscholtz Bay, southeastern Kotzebue Sound (Lloyd Lowry, personal communication). Our only sighting in this area was a moribund animal seen near Kotzebue in August. The relative lack of sightings in the western Beaufort and Chukchi Seas at a time when they are abundant in the eastern Beaufort Sea (Sergeant and Hoek 1974) suggests that most of the northern Alaska Beluga population spends the summer in Canadian waters and that few remain in offshore Alaskan waters, especially the Chukchi Sea.

Bering Sea

Surveys in the northern Bering Sea have been conducted in June, August, and October. Surveys in the southern Bering Sea have been conducted in February, March, April, June, August, and October. A total of 28 000 km of trackline was flown. We have no data on the distribution of Beluga in the northern Bering Sea during winter, and work needs to be done to delineate the winter distribution of the eastern Beaufort Sea population along the ice frontal zone in the northern Bering and southern Chukchi Seas. We do have several sightings from summer and fall indicating the presence of animals in Norton Sound near the mouth of the Yukon River. Summer sightings in the southern Bering Sea include observations in Bristol Bay and offshore in the vicinity of the Pribilof Islands. The latter substantiates the statement that Beluga "cannot be considered only as a coastal animal, as it also occurs in the open sea" (Kleinenberg et al. 1964). The lack of summer

FIGURE 4. Beluga Whale sightings, May–October 1975–1977.

sightings in the Kvichak River area, a known foraging location (Fish and Vania 1971) is attributed to the probability that Beluga were located in rivers and river mouths, a habitat which we did not survey. Sightings in Bristol Bay during the winter months were more numerous and are clustered in the northern portion of the bay. R. E. Gill (personal communication) has been studying bird and mammal populations year-round during 1976–1977 in Moller Bay using aerial and small-boat survey techniques. He has never observed Beluga in his study area.

Gulf of Alaska

Approximately 40 000 km of surveys have been completed in the Gulf of Alaska during the months of January, March, April, May, June, July, August, and October. Most sightings occurred in the Cook Inlet, especially in the vicinity of Tuxedni Bay. The Gulf of Alaska population has been considered to be geographically isolated and therefore genetically distinct from the Bering Sea population (Sergeant and Brodie 1969), and we have no evidence to the contrary after fairly intensive surveys south of the Alaska Peninsula extending from Kodiak Island west to the Aleutian Islands. Similarly Murie (1959) and others observed no Beluga in this area. The range of this population, however, does extend outside of Cook Inlet. We have sightings of Beluga in March and July near Kodiak Island and another near the entrance of Prince William Sound in March. Recently a group of 21 animals was sighted during late May in Yakutat Bay (Calkins and Pitcher 1977). Historically, Beluga have been observed as far

TABLE 1—Aerial survey sightings of Beluga Whales, *Delphinapterus leucas*, 1975–1977

Date	Location	Number	Notes[1]	Distance to land (km)	Bottom depth (m)
20 June 1975	63°26′N 164°00′W	1		22	5
2 July 1975	72°06′N 154°00′W	9	polynya	100	1800
2 July 1975	72°05′N 154°00′W	23	polynya; calves present	100	1800
16 July 1975	58°00′N 154°17′W	2		9	260
7 October 1975	60°25′N 152°00′W	1		1	5
7 October 1975	60°30′N 152°00′W	3		2	18
28 February 1976	58°18′N 162°00′W	6	polynya	31	40
29 March 1976	59°57′N 147°22′W	1		2	18
18 August 1976	71°45′N 151°47′W	2	polynya	102	1800
18 August 1976	71°45′N 151°40′W	2	polynya; cow-calf	110	1800
22 August 1976	66°53′N 162°36′W	1	moribund	beach	beach
26 August 1976	64°00′N 164°08′W	1		56	16
26 August 1976	64°00′N 163°08′W	1		19	16
26 August 1976	64°00′N 163°06′W	2		19	16
7 October 1976	64°25′N 161°22′W	1		1	5
11 October 1976	56°28′N 167°00′W	2		152	110
15 October 1976	58°14′N 157°32′W	1		3	2
7 March 1977	60°19′N 151°57′W	1		4	18
7 March 1977	60°08′N 152°38′W	3		1	10
8 March 1977	58°00′N 152°52′W	1		1	11
21 March 1977	58°11′N 157°30′W	3		1	5
13 April 1977	61°03′N 150°19′W	1		3	18
13 April 1977	60°12′N 152°35′W	1	calf	1	2
14 April 1977	60°58′N 150°04′W	1		2	8
25 April 1977	58°40′N 158°00′W	2		1	4
25 April 1977	58°38′N 157°56′W	3		4	5
25 April 1977	58°40′N 157°12′W	4		8	5
26 April 1977	58°45′N 158°30′W	1		8	12
17 June 1977	60°37′N 151°28′W	20		12	18

[1]Adults and open water except as noted.

south as the Washington coast (Scheffer and Slipp 1948) and bones have been found in middens on Kodiak Island (Kellogg 1936).

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Sphaeriid Mollusc Populations of Eight Lakes near Yellowknife, Northwest Territories

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Healey, M. C. 1978. Sphaeriid mollusc populations of eight lakes near Yellowknife, Northwest Territories. Canadian Field-Naturalist 92(3): 242–251.

Sphaeriidae were about twice as abundant in eight lakes near Yellowknife, Northwest Territories as previously reported for Precambrian Shield lakes. Depth distribution varied from lake to lake and there appeared to be no predictable distribution of Sphaeriidae with depth even among limnologically similar lakes. In the Yellowknife lakes, depth distribution was dictated by the relative abundance of individual species and their particular depth distribution in the lake. Nepionic forms were, relatively, most abundant in the littoral zone and, seasonally, most abundant in summer and autumn. Nepionic forms were more abundant later in the profundal of the lakes than in the littoral, suggesting delay of reproduction in deeper water. In general the sphaeriid clam community was dominated by one or two species in each lake and *Pisidium conventus* was the most common dominant, reaching densities in excess of 400/m^2 in the profundal of Drygeese Lake. *Pisidium conventus* was also the only species common in the profundal, all others being abundant only in the littoral zone, where some species reached densities in excess of 400/m^2. Three species, *Sphaerium lacustre*, *Pisidium nitidum contortum*, and *Pisidium nitidum pauperculum*, were uncommon members of the fauna of northern Precambrian Shield lakes. The presence of these species apparently reflects the intermediate nature of the Yellowknife lakes between typical Precambrian Shield lakes and lakes in sedimentary basins. The common species in the lakes appear to have similar habitat requirements and variations in abundance could not be related to any gross differences in the limnology of the Yellowknife lakes.

Key Words: Mollusca, Sphaeriidae, populations, northern Canada, clams distribution, abundance.

Sphaeriid bivalves are a numerically important component of the benthic community in lakes, and this importance is reflected in a considerable literature on these molluscs. Much of the literature, however, deals with classical taxonomic problems (Herrington 1962; Clarke 1973) or with growth and reproduction (Heard 1965; Meier-Brook 1970; Zumoff 1973; Ladle and Baron 1969; Danniel and Hinz 1976). Published descriptions of the distribution and abundance of sphaeriid clams within lakes are generally in the form of qualitative notes about individual species, or all species are treated together as a single group (Adamstone 1924; Herrington 1950; Oliver 1960; Rawson 1930, 1953, 1960; Särkkä 1972). Little attention has so far been paid to the numerical abundance of individual sphaeriid species. The purpose of this report is to describe, quantitatively, aspects of the distribution and abundance of sphaeriid species in eight lakes near Yellowknife, Northwest Territories.

Description of the Lakes

Frame, Long, and Grace lakes lie within 4 km of the city of Yellowknife, while the remaining five lakes lie 20 and 40 km away along the Yellowknife River valley (Figure 1). They range in size from 62 to 547 ha, and in depth from 6.5 to 34.5 m (Table 1). Secchi depths during open water in 1971 and 1972 ranged from 2.1 m (Grace Lake) to 9 m (Alexie, Baptiste, and Drygeese) (Table 1). Conductivity ranged from 89 μmho/cm (Alexie) to 332 μmho/cm (Frame) and pH from 7.4 (Baptiste and Long) to 8.5 (Frame). The chemical composition of the lakes was typical of oligotrophic lakes having partial shield drainage (Armstrong and Schindler 1971), except that reactive silicate was low (Healey and Woodall 1973a, b). Frame was atypical in having high conductivity and above-average concentrations of all ions measured, with the exception of silicate. This probably resulted from the proximity of the lake to the city and the addition of ions from local runoff (Healey and Woodall 1973a).

Frame and Long lakes were isothermal throughout the open-water season. All the other lakes stratified during the summer with a thermocline at 8–10 m and some oxygen depletion in the hypolimnion. Oxygen saturation in the hypolimnion never dropped below 25%, however, except in Grace and Chitty lakes (Healey and Woodall 1973a, b). Frame Lake,

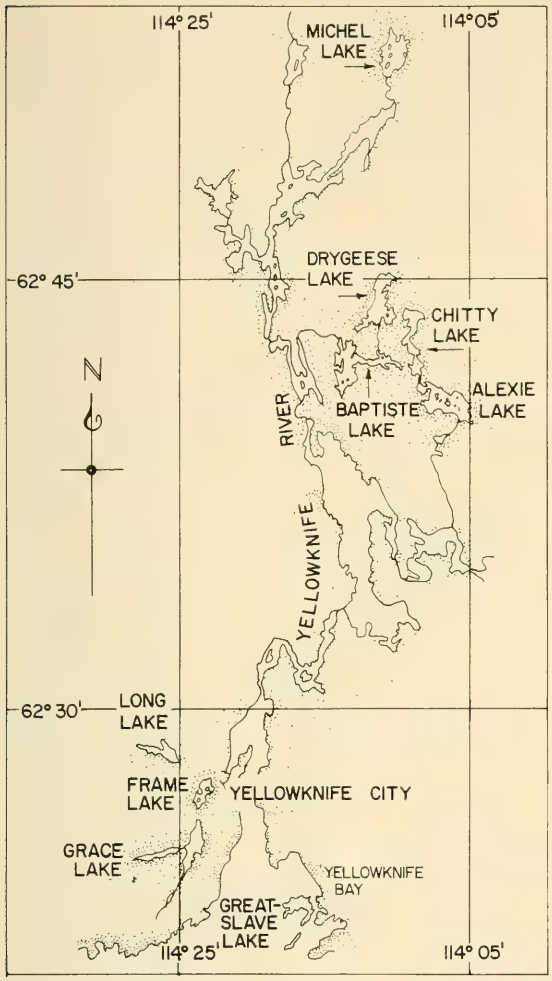

FIGURE 1. Map of the Yellowknife area, Northwest Territories, showing the locations of the eight lakes where abundance of sphaeriid molluscs was studied.

however, became anoxic under the ice in winter (G. Brunskill, personal communication). Surface temperature reached 18–20°C in July and epilimnion temperatures were commonly 16–18°C throughout the summer.

The littoral zone (as defined by Ruttner 1963) was of limited extent in all the lakes except shallow Long and Frame. Littoral substrates were generally rocky or sandy and there was little rooted vegetation in the deeper lakes. Frame and Long lakes had soft substrates below 1-m water depth. In the other lakes rocky and sandy sediments in the shallow littoral were replaced by clay and moss in the deep littoral and shallow profundal and silt in the deep profundal. Healey and Woodall (1973a, b), Healey and Kling (1975), and Healey (1977), give more details of the physical, chemical, and general biological characteristics of the lakes.

Materials and Methods

I took all samples with an Ekman grab, 15 × 15 × 22 cm tall. If the jaws or top doors of the grab did not close, or the surface of the sediment was within 5 cm of the top of the grab I repeated the sample. I sieved the samples in the field through a 600-μm mesh screen and preserved the sieve contents in 5% formalin for later sorting by hand under 10× magnification.

I sampled all eight lakes in 1971, but only Alexie, Baptiste, Chitty, and Drygeese in 1972. I sampled the lakes twice in 1971 between June and August, the visits to each lake being about 1 month apart, except for Michel which I sampled only once (July). I took 10 grab samples at four different locations in shallow lakes on each visit. In deep lakes I took five samples from the littoral

TABLE 1—Physical and chemical features of the eight lakes

Lake	Area, ha	Depth (m)		Secchi (m)		pH	Conductivity, μmho/cm
		Maximum	Mean	Range	Mean		
Frame	84	6.5	1.3	2.5–3.1	2.8	8.5	332
Long	157	7.0	—	4.5–5.0	4.8	7.4	108
Grace	62	18.0	6.6	2.1–3.8	3.0	8.1	138
Michel	345	22.0	—	—	5.3	7.7	100
Alexie	420	32.0	11.7	6.0–9.0	7.3	7.5	89
Baptiste	365	32.0	11.7	5.5–9.0	6.9	7.4	101
Chitty	325	20.0	6.9	4.8–6.9	5.7	7.5	103
Drygeese	547	34.5	14.5	6.0–9.0	7.2	7.5	111

and five from the profundal on each visit. In 1972 I sampled Alexie, Baptiste, Chitty, and Drygeese three times, 29 May – 3 June, 24–21 July, and 28 September – 5 October, along two transects in each lake. Transect 1 had six stations (five in Chitty) at equally spaced depths from the shallow littoral to the deep profundal, and transect 2 had three stations (four in Chitty). I took three grab samples at each station on transect 1 and two at each station on transect 2.

Neither the sampling in 1971 nor in 1972 was really adequate for a rigorous analysis of population sizes in sphaeriid species. The appropriate design, one of stratified random sampling, could not be established a priori because the necessary information on sphaeriid distribution and relative abundance was not available.

Variance and mean were strongly correlated in the untransformed sample counts, and the variance-to-mean ratio normally exceeded 40, indicating highly contagious distributions of Sphaeriidae. Logarithmic transformation of sample counts removed most of the correlation between variance and mean. All statistical comparisons were, therefore, performed on logarithms of the abundance estimates and the means presented in the tables are geometric means. Abundance is used throughout the paper to mean numbers per square metre.

Individual species tended to occupy specific depth zones in the lakes, so that finding a representative measure of average abundance posed a problem. Values presented in the tables are the geometric means for the whole lake or a specified portion of the lake. Abundance at the typical depth for each species is considered in the accounts of individual species.

My use of geometric means makes direct comparison of my results with published data on sphaeriid abundance difficult, as published values are arithmetic means. In spite of this difficulty, I feel that the geometric means are more realistic estimates of central tendency in the data, and thus better measures of "average" abundance. Because the sample counts were positively skewed, the geometric means presented are less than the corresponding arithmetic means. The degree of difference depends on the degree of skew, however, so that there is no single conversion coefficient.

Results and Discussion

The total population of benthic organisms retained by the 600-μm sieve ranged from 404 to 3688 organisms/m^2 in the lakes, while Sphaeriidae ranged from 42 to 971/m^2. Sphaeriidae contributed most to the benthic fauna of Long Lake (60%) and least to Baptiste (2.6%) (Table 2). By comparison with other oligotrophic lakes on the Precambrian Shield, Sphaeriidae were relatively abundant in the Yellowknife lakes. Arithmetic mean numbers of Sphaeriidae in 17 Saskatchewan lakes ranged from 8 to 548/m^2 (Rawson 1960; Koshinsky 1965). The average in Great Slave Lake was 175/m^2 (Rawson 1953). These arithmetic means are comparable in size with the geometric means for the Yellowknife lakes, but the arithmetic means will be higher than the corresponding geometric means. Arithmetic means for the Yellowknife lakes were approximately 925–1198 sphaeriids/m^2. Thus, the comparison, although tentative because of the different averaging technique used, suggests that Sphaeriidae were about twice as abundant in the Yellowknife lakes as reported elsewhere. Percentage contribution to the bottom fauna was similar to that in other lakes, however, except for Long Lake, in which it was high. The Yellowknife lakes were rich in bottom fauna generally, not just Sphaeriidae (Healey 1977).

Sphaeriidae were present at all depths sampled in Alexie, Baptiste, Chitty, and Drygeese in 1972, but their abundance varied with depth (Table 3). The depth distribution was also unique to each lake. In Alexie there were two peaks of abundance, one in the shallow littoral (757/m^2) and one in the mid-profundal (739/m^2), with minima in the shallow profundal and deep profundal. In Baptiste there was a single peak in the shallow littoral (840/m^2) and numbers declined rapidly with increasing depth. In Chitty there was a single peak in the deep littoral (890/m^2) with minima in the shallow littoral and profundal. Drygeese had peaks in abundance in the shallow littoral (381/m^2) and mid-profundal (624/m^2) similar to abundance peaks in Alexie, but the peaks were less prominent. Comparison of littoral and profundal samples from Grace and Michel lakes in 1971 indicated that Sphaeriidae were abundant only in the littoral zone (Table 4), suggesting

TABLE 2—Percentage composition of the Sphaeriidae in the eight lakes. Abundance estimates are for 1971 in Frame, Long, Grace, and Michel and for 1971 and 1972 averaged in Alexie, Baptiste, Chitty, and Drygeese

	Lake							
	Frame	Long	Grace	Michel	Alexie	Baptiste	Chitty	Drygeese
Total benthos/m^2	3205	535	404	853	2574	2808	935	3688
Total Sphaeriidae/m^2	971	321	42	58	296	73	72	177
Total Sphaeriidae %	30.3	60.0	10.4	6.8	11.5	2.6	7.7	4.8
Immature and adult forms %	100	67	74	59	71	57	82	68
Nepionic forms %	0	33	26	41	29	43	18	32
Species composition%								
Pisidium conventus	0.9	13.5	8.3	39.4	53.6	27.7	61.0	77.0
lilljeborgi	3.3	21.0	22.5	25.6	12.6	3.5	7.0	5.2
nitidum	23.7	10.2	7.5	0.0	2.8	3.2	<0.1	2.9
nitidum-contortum	0.9	6.4	3.8	9.8	12.5	19.0	10.0	5.6
nitidum-pauperculum	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0
ventricosum-rotundatum	6.6	8.2	5.0	2.0	5.4	14.5	8.7	5.7
casertanum	0.0	19.3	40.0	13.8	1.1	3.6	4.3	0.0
subtruncatum	6.6	8.6	0.0	0.0	8.2	24.1	3.0	1.6
walkeri	0.0	2.7	0.0	0.0	0.6	1.6	1.7	0.0
ferrugineum	5.6	0.0	0.0	0.0	2.3	2.9	3.4	0.0
idahoense	0.0	6.4	12.5	9.8	0.5	0.0	0.4	0.0
cf. *milium*	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Sphaerium nitidum	4.0	2.7	0.0	0.0	0.1	0.0	0.5	1.9
*lacustre**	48.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0

*Subgenus *Musculium* (Link).

depth distributions in these lakes similar to that in Baptiste. Rawson (1930, 1953) and Oliver (1960) described the depth distribution of Sphaeriidae in Lake Simcoe, Great Slave Lake, and Lac la Ronge. In Lake Simcoe Sphaeriidae were most abundant between 15 and 20 m (120/m^2) and least abundant near the surface and in the deep profundal. In Great Slave, Sphaeriidae were most abundant in the 0 to 5-m depth zone (636/m^2), and declined continuously in abundance with depth. In Lac la Ronge, the depth distribution was different in Hunter Bay and the main lake. In Hunter Bay, Sphaeriidae were most abundant (2000/m^2) at 15–20 m depth and least abundant in shallow water. In the main lake, however, maximum abundance was in the littoral (150–200/m^2). Clearly, there is no predictable pattern of sphaeriid abundance with depth, even among limnologically similar lakes. Presumably the depth distribution of Sphaeriidae in the lakes is related to the species mix, and the particular limnological conditions in the lakes. There were no obvious differences in the limnology of Alexie, Baptiste, Chitty, and Drygeese lakes that would account for the different distributions, however, (Healey and Woodall 1973b), nor were there sufficient differences in species composition among these four lakes to account for the differences in distribution (Table 2).

Many of the Sphaeriidae examined were nepionic forms (recent post-embrionic forms too immature for species identification). The proportion of nepionic forms in the populations ranged from 0% in Frame to 43% in Baptiste (Table 2). Why there were no nepionic forms in Frame Lake is not clear. Presumably the presence of nepionic forms reflects recent release of litters from the parent animals. Their abundance should be greatest in early summer when most species release litters (Ladle and Baron 1969; Heard 1965; Danniel and Hinz 1976). Nepionic forms constituted 5% or less of samples taken in early spring 1972 from Alexie, Baptiste, Chitty, and Drygeese. Maximum contribution to samples was in summer in Alexie and Drygeese (21 and 39%) and in autumn in Baptiste and Chitty (72 and 14%) (Table 5). These observations suggest that summer and autumn were the most important periods for release of embryos. Nepionic forms were most abundant in the littoral of all the lakes (Table 4), and reached their greatest proportional representation in the shallow littoral in Alexie

TABLE 3—Abundance of Sphaeriidae at different depths in Alexie, Baptiste, Chitty, and Drygeese lakes in 1972

	Depth												
	0–5	5–10	10–15	15–20	20–25	25–30	0–5	5–10	10–15	15–20	20–25	25–30	30–35
	Alexie						Baptiste						
P. conventus	123	128	77	88	739	68	66	16	77	25	26	2	
lilljeborgi	7	173	85	1	0		13	8	0				
nitidum	19	3	12	0									
nitidum-contortum	128	28	0				124	20	0				
ventricosum-rotundatum	12	45	0	1	0		80	0					
casertanum	8	10	0				27	0					
subtruncatum	80	21	0				147	33	1	0			
walkeri	0	0	12	0			0	8	0				
ferrugineum	21	13	0				6	8	5	0			
idahoense	0	9	0										
S. nitidum	2	0											
Nepionic forms	357	304	90	3	0		377	186	< 1	7	6	0	
Total Sphaeriidae	757	734	276	93	739	68	840	279	83	32	32	2	
	Chitty						Drygeese						
P. conventus	15	331	156	315			117	56	116	249	475	118	13
lilljeborgi	3	79	12	2			31	4	0				
nitidum							0	10	0				
nitidum-contortum	36	66	0				33	2	0				
ventricosum-rotundatum	31	49	< 1	0			20	1	0	0	36	8	0
casertanum	2	44	10	0									
subtruncatum	2	21	3	0			13	0					
walkeri	2	18	0										
ferrugineum	0	42	6	2									
idahoense	0	5	2	0									
S. nitidum	0	6	1	0			0	6	0				
Nepionic forms	49	229	25	2			167	82	108	100	113	22	3
Total Sphaeriidae	140	890	216	321			381	161	224	349	624	148	16

TABLE 4—Abundance/m^2 of Sphaeriidae in the littoral (L) and profundal (P) zones of the eight lakes. Data for Alexie, Baptiste, Chitty, and Drygeese lakes are for 1971 and 1972 averaged, the others are 1971 data only

	Frame	Long	Grace		Michel		Alexie		Baptiste		Chitty		Drygeese	
	L	L	L	P	L	P	L	P	L	P	L	P	L	P
P. conventus	9	29	112	0	369	1	150	123	48	10	140	14	93	88
lilljeborgi	32	45	307	0	240	0	68	5	12	0	24	< 1	27	0
nitidum	231	22	103	0	0	0	14	0	23	0	2	0	13	0
nitidum-contortum	8	14	51	0	92	0	94	0	26	0	45	0	19	0
nitidum-pauperculum	0	0	0	0	0	0	< 1	0	0	0	0	0	0	0
ventricosum-rotundatum	64	17	68	0	18	0	39	< 1	50	< 1	47	< 1	19	2
casertanum	0	42	549	0	129	0	12	0	13	0	16	< 1	0	0
subtruncatum	64	18	0	0	0	0	43	< 1	69	< 1	12	< 1	4	0
walkeri	0	6	0	0	0	0	5	< 1	3	0	6	0	0	0
ferrugineum	54	0	0	0	0	0	22	0	6	< 1	8	< 1	0	0
idahoense	0	14	168	0	92	0	2	0	0	0	2	< 1	0	0
cf. *milium*	0	1	0	0	0	0	0	0	0	0	0	0	0	0
S. nitidum	39	6	0	0	0	0	3	< 1	0	0	3	0	10	0
lacustre	470	2	0	0	0	0	0	0	0	0	0	0	0	0
Nepionic forms	0	105	467	0	664	0	341	8	264	2	117	< 1	90	32
Total Sphaeriidae	971	321	1825	0	1604	1	793	137	514	13	422	15	275	122

TABLE 5—Seasonal variation in nepionic forms/m^2 and proportional representation of nepionic forms by depth zone in Alexie, Baptiste, Chitty, and Drygeese lakes in 1972. Sp = spring, Su = summer, Au = autumn

	Alexie			Baptiste			Chitty			Drygeese		
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au
Total Sphaeriidae	666	241	221	192	59	65	233	334	238	214	162	226
Nepionic forms	3	51	21	5	19	47	11	9	34	5	63	12
% nepionic	<1	21	10	2	32	72	5	3	14	2	39	5
By depth zone, m												
0–5	27	62	53	29	80	44	22	58	43	12	51	72
5–10	16	64	33	30	65	82	31	9	33	0	84	49
10–15	0	47	56	9	26	92	15	0	18	29	78	35
15–20	0	24	0	0	54	57	0	0	1	20	80	0
20–25	0	0	0	0	100	100				8	28	4
25–30	0	0	0	0	0	0				0	33	0
30–35										100	100	0

and Chitty and in the deep littoral in Baptiste and Drygeese (Table 3).

The depth distribution of nepionic forms during the spring, summer, and autumn of 1972 in Alexie, Baptiste, Drygeese, and Chitty suggests that embryos are released earlier in the shallow water than in the deep water. Drygeese was exceptional in having nepionic forms in the profundal in spring, but the numbers were small (Table 5).

The greater proportion of nepionic forms in the littoral suggests that reproductive activity is greater there. The proportion of nepionic forms in the littoral and profundal, however, must also be related to the life history patterns of the species. The profundal of Alexie, Baptiste, Chitty, and Drygeese was dominated by *Pisidium conventus*, which is relatively long-lived and has small litters (Heard 1965). The littoral zone of these lakes, on the other hand, had numerous species, some of which are short-lived and/or have large litters (Heard 1965). Thus, species composition alone may account for the greater proportion of nepionic forms in the littoral.

Twelve species of *Pisidium* and two of *Sphaerium* occurred in the lakes. *Pisidium conventus* was the dominant species in Michel, Alexie, Chitty, Baptiste, and Drygeese, composing 28–65% of all Sphaeriidae. *Sphaerium lacustre* was dominant in Frame Lake, *P. lilljeborgi* in Long Lake, and *P. casertanum* in Grace Lake (Table 2). Four species were present in all the lakes (*P. conventus*, *P. lilljeborgi*, *P. nitidum contortum*, *P. ventricosum rotundatum*), and two were present in only one lake (*P. nitidum pauperculum*, and *P.* cf. *milium*). Long and Alexie lakes had the most species (12), while Michel had fewest (6). One species was numerically dominant over all others in five of the lakes, while two species dominated in the other three. Comparison of species composition and relative abundance indicates that Frame Lake was different from all the others. Grace and Long lakes were similar in that they were dominated by *P. lilljeborgi* and *P. casertanum*, but in species composition Grace resembled Michel, and Long resembled Alexie, Baptiste, and Chitty. Drygeese resembled Alexie, Baptiste, and Chitty in its dominant species but was similar to Michel in overall composition.

The mix of species recorded from the lakes is fairly typical of northern lakes, most species being those which are considered cold-loving, or which have previously been described from northern lakes (Herrington 1950, 1962; Heard 1963; Oliver 1960; Holmquist 1975; Clarke 1973). The occurrence of only one or two abundant species in each lake community is consistent with observations on Great Slave and Athabaska lakes (Herrington 1950; Rawson 1947, 1953) where only *P. conventus* and *P. subtruncatum* were common species, the others being represented by only a few specimens in hundreds of dredgings.

The characteristic depth distributions of Sphaeriidae in the lakes appear partially related to the relative abundance of different species, if not directly to the mix of species. *Pisidium*

conventus had a bimodal depth distribution, with peaks in the littoral and mid-profundal (Table 3). The dominance of this species in Alexie and Drygeese resulted in the peak in abundance in the profundal. The other species were restricted to the littoral, or were rare in the profundal (Table 3). Species other than *P. conventus* contributed most to the community in Baptiste so that there was only a single peak in abundance in the littoral in this lake. Species that were most abundant in the shallow littoral in Baptiste and Drygeese tended to be more abundant in the deep littoral of Alexie and Chitty (Table 3). This difference in distribution among littoral species resulted in a peak of abundance in the deep littoral of Chitty rather than the shallow littoral as in Baptiste. Why the distribution of these species differed among the lakes is not clear. Similar subtle differences between Alexie and Chitty as a pair and Baptiste and Drygeese as a pair were evident in other biological parameters, however (Healey and Kling 1975; Healey 1977).

I subjected the estimates of abundance for Alexie, Baptiste, Chitty, and Drygeese lakes to two analyses of variance (a Lake × Transect × Season × Species analysis of the 1972 data and a Lake × Year × Species analysis of the combined 1971 and 1972 data). In the analysis of the 1972 data there were significant differences only among lakes ($F = 9.199$, $P < 0.01$) and species ($F = 41.559$, $P < 0.001$), not among seasons and transects. The lake by species-interaction term was also significant ($F = 1.979$, $P < 0.05$), indicating different species contributions in the lakes. In the analysis of the combined 1971 and 1972 data differences among species were significant ($F = 25.6$, $P < 0.001$) as were interactions among lakes and species ($F = 2.262$, $P < 0.05$) and species and years ($F = 3.459$, $P < 0.01$). Differences between years and lakes were not significant. The species-by-year interaction suggests that individual species may have varied in abundance from year to year. Inspection of the data on abundance, however, revealed no obvious and consistent changes in species abundance in the four lakes.

It is difficult to know how much confidence to place in these analyses, especially the interaction terms, because of the high variability in individual abundance estimates, and the different sampling procedures used in 1971 and 1972. They do indicate, however, that the differences in abundance observed among the Yellowknife lakes were statistically significant, and that the differences in relative species composition observed among the four lakes sampled in 1972 were also significant.

Cluster analysis of the sample data for Alexie, Baptiste, Chitty, and Drygeese (Association based upon the Euclidian distance between species in the species × sample matrix; see Duewer et al.[1]) indicated significant separation between *P. conventus* and all other species, but no other significant groupings of species. *Pisidium conventus* presumably separated out because of its occurrence alone in profundal samples. Each of the remaining common species was found together with almost every other species in the samples, suggesting little or no habitat segregation within the lakes, at least on the scale of an Ekman dredge sample. The results do suggest, however, that for the Yellowknife lakes it is appropriate to compare the littoral zones of the lakes separately from the profundal zones. This puts a somewhat different perspective on the comparison of total abundance and the contribution of individual species in the lakes (Table 4). Comparison of Frame and Long lakes with the others also becomes more meaningful, since Frame and Long had no profundal. When only littoral zones are compared, Frame and Long lakes no longer stand out as having the most sphaeriids. Grace and Michel lakes, which on a whole-lake basis, had relatively small sphaeriid populations, had the densest populations in their littoral, almost twice as dense as Frame Lake (Table 4). Sphaeriidae were absent from the profundal of Grace, and only a few *P. conventus* occurred in the profundal of Michel. Sphaeriidae were least abundant in the littoral zones of Long and Drygeese lakes.

Even in the littoral zone, *P. conventus* was the most abundant species overall (Table 4). The only other species that could be generally

[1]D. L. Duewer, J. R. Koskinen, B. R. Kowalski. 1977. "ARTHUR": a package of programs for pattern recognition. Available from B. R. Kowalski, Laboratory for Chemometrics, Department of Chemistry, BG-10, University of Washington, Seattle, Washington 98195, USA.

considered abundant over all the lakes was *P. lilljeborgi*. Both these species are widely distributed in central and arctic Canada (Clarke 1973), and *P. conventus* is one of the best studied of the Sphaeriidae (Heard 1963). Both are reported from a wide variety of substrate types (Herrington 1962) and are known to occur to considerable depth (Heard 1963). Meier-Brook (1969), however, reported a significant preference for fine substrates in *P. lilljeborgi*. In the Yellowknife lakes, *P. conventus* had a bimodal depth distribution, as previously noted. The greatest population density observed for this species was 739/m^2 at 20–25 m depth in Alexie, and maximum abundance was generally below the thermocline in this species. The presence of a second maximum in the littoral zone, however, attests to the adaptability and probable high competitive ability of this species. *Pisidium lilljeborgi* was most abundant in the littoral zone, reaching maximum densities of 307/m^2 and 240/m^2 in Grace and Michel lakes (Table 4). *Pisidium lilljeborgi* did not occur below the 15–20 m depth stratum in the Yellowknife lakes. This is at odds with previous records for the species, which show it occurring to 50 fathoms (92 m) (Heard 1963). *Pisidium lilljeborgi* was most abundant in Grace and Michel lakes, but was an important contributor to the fauna of the other lakes (Table 4).

Pisidium nitidum, *P. casertanum*, *P. idahoense*, and *S. lacustre* were each abundant in one of the eight lakes, but were relatively rare or absent from most of the lakes. *Pisidium nitidum* and *S. lacustre* were abundant only in Frame Lake, although *P. nitidum* was also moderately abundant in Grace Lake (Table 4). *Pisidium nitidum* is widely distributed in central and arctic Canada and is found on a wide variety of substrates, although Meier-Brook (1969) identified a significant preference for coarser substrates in this species. The species occurred only in the littoral zone, and its abundance in the soft substrate of Frame Lake appears contradictory to its supposed preference for coarse substrates. *Spaherium lacustre* has been recorded from only a few localities north of 60°N (Clarke 1973) and is reported to have a preference for muddy substrates (Herrington 1962). This is one of three species recorded from the Yellowknife lakes that is not typically a northern species. Its abundance in Frame Lake may be related to the presence of soft organic substrates and atypical ionic concentrations in the lake. *Pisidium casertanum* was abundant only in Grace Lake and moderately abundant in Michel. This species is nearly cosmopolitan, and is probably the most common *Pisidium* species in Canada (Clarke 1973). It is, therefore, surprising that *P. casertanum* was not more common in the Yellowknife lakes. Conditions in these lakes appear to have favored *P. conventus* and *P. lilljeborgi* over *P. casertanum*. In a survey of lakes on the north slope and arctic coastal plain in Alaska and western Canada, Holmquist (1975) found *P. casertanum* more commonly than *P. conventus*. *Pisidium idahoense* was abundant only in Grace Lake (Table 4). This species is widely distributed in Precambrian Shield lakes, and is generally considered to be cold-loving (Herrington 1962). Again, it is surprising that this species was not more abundant.

Pisidium nitidum contortum and *P. ventricosum rotundatum*, although never abundant, made a significant contribution to the fauna of most of the lakes (Table 4). *Pisidium nitidum contortum* is the second species not typically found in the north. Living populations of *P. nitidum contortum* have not previously been reported from outside central Ontario, although fossils have been reported from Saskatchewan and northern Alberta. The presence of apparently healthy specimens in the Yellowknife lakes confirms the hypothesis of a historically wide distribution of this morph and demonstrates its continued survival in locations outside Ontario (Clarke 1973).

The remaining species were moderate to rare in abundance in the lakes, never exceeding 50–70/m^2 in the littoral zone. The third distributional anomaly is *P. nitidum pauperculum*, four specimens of which occurred in one of the samples from Alexie Lake. This species has not previously been reported from lakes on the Precambrian Shield, although it is known from shield margin lakes (Clarke 1973). Its presence in the Yellowknife lakes may be due to the relatively high calcium content of these lakes in comparison with other shield lakes (Healey and Woodall 1973b).

Although the factors determining the abundance of individual sphaeriid species in the eight lakes cannot be identified at this stage,

certain conjectures may be made. The sphaeriid communities in the lakes, although fairly typical of northern lakes, included species (*S. lacustre*, *P. nitidum contortum*, and *P. nitidum pauperculum*) indicative of more nutrient-rich or more southern lakes. This is in keeping with the chemical characteristics of the lakes, which were similar to those of lakes on the margin of the shield rather than to those of lakes with a completely shield drainage (Armstrong and Schindler 1972). Further, the degree of difference in community structure and abundance of individual species among the lakes was related to the degree of difference in their limnological conditions. Alexie, Chitty, Baptiste, and Drygeese were most similar in their limnology and in their sphaeriid communities. Frame and Long lakes were most unique, limnologically, especially Frame, and this was reflected in their sphaeriid communities. It would be surprising if the sphaeriid community were not related to the limnological conditions in the lakes; however, the high degree of association among the species in the littoral zones of the lakes suggests that all the common species were adapted to a wide variety of living conditions. The reasons for the considerable differences in their abundance among the lakes must, therefore, have to do with rather subtle differences in the lakes, rather than with general limnological conditions. Further study of the limnological requirements of the individual species will be required before it will be possible to explain differences in species composition and abundance of the sort described here.

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Summer Movements and Feeding by Moose in Western Quebec

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Joyal, R. and B. Scherrer. 1978. Summer movements and feeding by Moose in western Quebec. Canadian Field-Naturalist 92(3): 252–258.

Summer observations on activity of Moose (*Alces alces*) in western Quebec showed that diurnal aquatic feeding lasted for less than 1 h. During most of the day Moose ate the leaves of shrubs or ruminates. White Birch (*Betula papyrifera*) and willows (*Salix* spp.) were preferred. Wind (up to 24 km/h) and rain did not affect movements on roads. Sixty percent of these movements occurred at night. After the first half of August, Moose leave their summer range but come back again in early September at the beginning of the rut period.

Key Words: Moose, summer activity, movements, summer diet, habitat, western Quebec.

Des observations sur les activités estivales de l'orignal (*Alces alces*) dans l'ouest du Québec ont démontré que durant la période diurne, l'orignal se nourrissait de plantes aquatiques durant moins de 1 h en moyenne. Le reste de la journée était utilisé pour l'ingestion et la rumination de feuilles d'arbustes dont les préférés étaient le bouleau blanc (*Betula papyrifera*) et les saules (*Salix* spp.). Soixante pourcent de déplacements sur les chemins se firent la nuit. La pluie et les vents (inférieurs à 24 km/h) n'affectèrent pas ces déplacements. Après la deuxième semaine d'août, les orignaux quittaient temporairement leur territoire d'été pour y revenir à la période d'accouplement qui semblait commencer vers la deuxième semaine de septembre.

Mots clefs: orignal, activités estivales, deplacements, nourriture estivale, habitat, ouest du Québec.

The summer activities and diet of North American Moose are poorly documented. In a review of food habit studies (Peek 1974), only nine of 41 reports offered summer observations, of which three were from central and eastern Canada. Bouchard (1967) and de Vos (1958) also worked in central and eastern Canada. Bouchard (1967) reported that Moose on the Péribonka River ceased aquatic feeding by mid-August while de Vos (1958) observed aquatic feeding in Ontario until the month of October.

De Vos (1958) noted that the distribution of Moose along the lakes and rivers in Ontario seemed to be related to the abundance and the distribution of aquatic vegetation, but on the Péribonka (Bouchard 1967) occurrence of Moose was related also to weather conditions. Summer activity was also noted by Grenier (1974), who observed most road kills of Moose at night. Recently in Maine, Dunn (1976) found that in summer, Moose inhabited mixed stands and that the peak of aquatic feeding occurred from the fourth week of June until the fourth week of July. Dunn (1976) observed that the peak of daily aquatic activity took place between 1200 and 1400 hours in contrast to observations of Bouchard (1967) and de Vos (1958) who noted aquatic activity mostly at sunrise and at sunset. This aspect of Moose behavior is important in nature-observation programs in parks.

The purpose of this study was to obtain a better knowledge of the diet and use of habitat by Moose in summer. Feeding activity in both terrestrial and aquatic habitats was examined. Daily activity, and the influence of weather on the movements of moose were also studied. The study was part of a long-term project on Moose and their habitat in western Quebec.

The study area was located in and near Mont-Tremblant Provincial Park, about 120 km north of Montreal. It is in the Laurentian Section of the Great Lakes – St.-Lawrence Region (Rowe 1972). The gently hilly terrain is covered with a mixed forest dominated by Black Spruce (*Picea mariana*), White Birch (*Betula papyrifera*), Trembling Aspen (*Populus tremuloides*), Balsam Fir (*Abies balsamea*), and Yellow Birch (*Betula alleghaniensis*). Fire succession stands of Jack Pine (*Pinus divaricata*) occupy sandy areas. Altitude varies between 400 m and 800 m. The region abounds with numerous lakes which provide plentiful summer food for Moose. The area is known to support about four Moose per 100 km^2 (Michel Crête, personal communication).

Methods

Feeding and Diet

Aquatic feeding was observed at a eutrophic pond approximately 15 km east of Mont-Tremblant Park. Observations 2 or 3 days per week from daybreak until dusk were made from 28 June to 15 September 1972, and totalled 370 h. The pond provided good food supply, but was situated near an inhabited area. Observations on Moose feeding were tallied along with the data, the time of day, the length of feeding periods, and the weather conditions.

One mature bull, one young bull, and a cow with two calves were using the pond at the start of observations. One calf was hit by a car in late June, however, and the other calf disappeared in mid-July. When observations began at the end of June, the Moose had already used the pond for almost 2 wk. By the end of July, the pool was almost entirely covered with Bullhead-lily (*Nuphar variegatum*), Bur-reed (*Sparganium angustifolium*), and Watershield (*Brasenia schreberi*) among which grew some species of submerged pond weed (*Potamogeton* spp.). Moose grazed on all species and no effort was made to ascertain the proportion of each in the diet.

Terrestrial feeding was observed in 1973 near Lac Laverdière, a remote area in the northern part of the Mont-Tremblant Park. This study area was situated at the end of a lumber road. The area was logged 10 yr before and is considered good Moose range. Although it was also clear cut, many patches of conifers were left and served as winter cover. Because of its remote location, the area was almost ignored by fishermen, permitting observations of undisturbed animals, a situation contrasting with the previous year's conditions.

Terrestrial feeding was determined by a modified version of the aggregate percentage method of Passmore and Hepburn (1955). Seventy-seven plots, 1×20 m, were randomly located in feeding sites. In each plot, the number of stems per species (availability) was tallied. Also, the percentage of available current-year growth (up to 2 m) with leaf removal evidence (degree of browsing) was estimated for each stem of each species, and each stem was assigned to one of three percentage classes (Passmore and Hepburn 1955).

The relative density, or the availability of each species, was calculated by the mean stem density per plot. Preference is based on the ratio of availability over the importance of each species in the diet (Joyal 1976).

When possible, direct observations of terrestrial activity by Moose were noted in order to evaluate the relative importance of terrestrial feeding.

Habitat Use and Movements

Habitat use and daily movements were also studied in the same area. Distribution of use between habitats was first assessed by a preliminary track survey in June. Afterwards, 15 stations were chosen which took into account habitat diversity and occurrence of tracks. A station consisted of a 100-m section of sandy road (transect); this is a version of Wright's method (Bider 1968). The 15 sand transects were dispersed along a 16-km secondary road near major habitats such as ponds, swamps, and cutover. The number of transects was limited by the time required to complete the 16-km circuit. Some habitat can be represented by one to three transects.

The circuit was visited four times daily from 8 July to 31 August with the schedule alternating weekly as follows: one week at 0000, 0600, 1200, and 1800 hours; the next week at 0300, 0900, 1500, and 2100 hours. At the start of each run (tracking session), weather conditions such as cloudiness, rain, temperature, and wind velocity were noted. At each run, tracks of moose found in a transect were recorded and erased with a broom. We calculated tracks/transect ratio for habitat use and tracks/run ratio for daily activity and weather influence on this activity. Chi-square and *t*-tests for simple random variables and for ratios are used in all statistics with a risk coefficient of 5%. The results include 2.025 transect readings (135 runs at 15 transect readings each). Statistical tests follow Cochrane (1963).

Observations

Aquatic and Terrestrial Feeding

Aquatic feeding occurrence increased from the end of June until the second half of July. Afterwards, use of aquatics dropped drastically during the first two weeks of August (Figure 1).

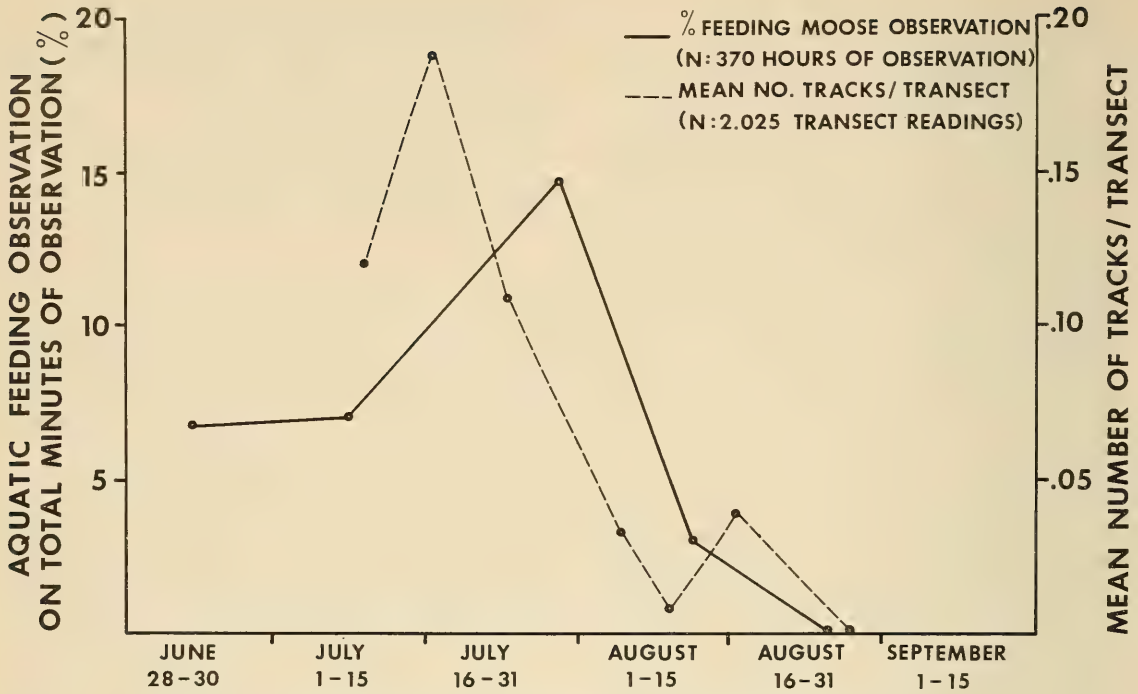

FIGURE 1. Moose observations in western Quebec during the summers of 1972 and 1973.

No Moose were seen after this period despite continuous observations until 15 September. There was no significant difference between observation occurrence in June and July but aquatic feeding during this period is significantly different from that in the month of August ($P < 0.05$). Furthermore, there was no significant difference ($P > 0.05$) in aquatic feeding between different daily periods although a peak was noted between 1200 and 1500 hours.

Moose spent an average (±SE) of 54 ± 18 min (range 5 min to 2 h 45 min, n = 18) in the water. Once the Moose were in the pond, only the noise of a passing logging truck on the road 150 m nearby could scare them. They paid no attention to human voices or dogs' barking.

The period during which feeding Moose kept their heads submerged was short and varied according to sex. The average for males was 18 ± 2.2 s (range 5–25 s, n = 20) whereas that of females is 8 ± 0.7 s (range 4–11 s, n = 24). We registered a mean of 20 ± 1.7 s of mastication for the bulls (range 10–26 s, n = 20) and a mean of only 10 ± 0.7 s for the cow (range 4–12 s, n = 24).

Rain affects aquatic feeding behavior. Moose were seen on all 20 rainless days but only four out of nine (44%) rainy days.

Most terrestrial feeding was focused on only four species (Table 1). Mountain Maple (*Acer spicatum*) was rare whereas Pin Cherry (*Prunus pensylvanica*) was by far the most important species. As many as 70% of the White Birch stems were utilized in summer but Mountain Maple was the least used, with traces only.

The highest percentage of eaten leaves (degree of browsing) is found on White Birch (26%) followed closely by willows (22%). Taking into account the relative density of each species, the percentage of stems used of each species and the degree of browsing, we can assume that Pin Cherry, because of its abundance, represented two-thirds of the summer Moose diet in that area. A fourth of the diet consisted of White Birch. Willows, whose presence was scanty, and aspen accounted for 10% each. The degree of browsing of willows does not vary significantly from that of other species ($P > 0.05$) but degree of browsing of Trembling Aspen differs greatly from that of White Birch ($P < 0.01$) and of Pin Cherry ($P < 0.05$; Table 1).

Finally Moose prefer first of all White Birch

TABLE 1—Summer moose browse analysis for Lac Laverdière sector, Mont-Tremblant Park, Québec

Shrub species	Relative density (availability)	Individuals browsed (%)[1]	Degree of browsing (%)[1]	Diet (%)	Preference[2]
White Birch (*Betula papyrifera*)	16	70	26[c, f]	25	1
Willows (*Salix* spp.)	5	65[a, b]	22[c, d, e]	6	2
Pin Cherry (*Prunus pensylvanica*)	68	55[a]	20[d, f]	65	3
Trembling Aspen (*Populus tremuloïdes*)	10	40[b]	12[e]	4	4
Mountain Maple (*Acer spicatum*)	1	tr.	tr.	tr.	5
Totals	100			100	

[1]There is no significant difference ($P > 0.05$) between percentage followed by same letter.
[2]Preference = ratio of the proportion of the diet over the availability.

leaves, then willow leaves. Pin Cherry, the most browsed species, was eaten proportionally to its relative abundance.

Summer Movements

Daily road activity is mostly nocturnal (Figure 2). The greatest number of tracks was recorded between 0000 and 0300 hours and 60% of the movements occurred between 2100 and 0600 hours. The amount of movement on the road differs at night from movement in the day ($P < 0.05$) but no difference was found between each 3-h period.

Movements varied among the different habitats as illustrated in Figure 3. The transect located between two ponds intercepted the greatest number of tracks. The least crossed transect was situated between a mature Sugar Maple (*Acer saccharum*) – Yellow Birch stand and a swamp. The difference in movement between these two sectors is highly significant ($P < 0.1$); however, no differences between the other stands are significant.

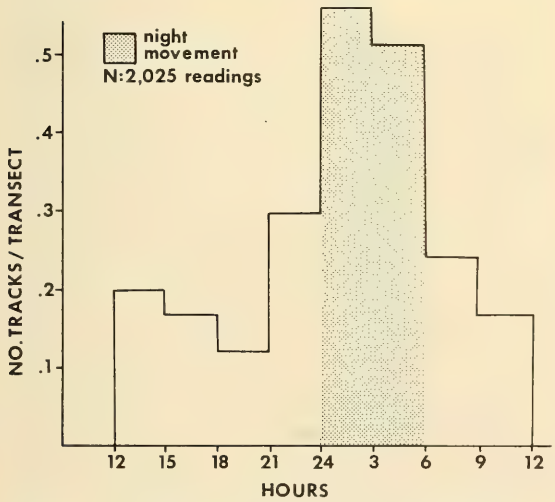

FIGURE 2. Diurnal pattern of moose activity as indicated by the track index in Mont-Tremblant Park.

Moose seemed to be more active on clear days, but no significant differences were found in movements between clear, cloudy, and rainy days. No significant difference in Moose movements in this open forest area was observed ($P > 0.05$) at various wind velocities up to 24 km/h. Winds over 24 km/h reduced movement on the road and the decline in the movements was highly significant ($P < 0.01$). The highest track/run ratio of 1.47 occurred when wind velocity was between 16–24 km/h (225 readings). This ratio fell to 0.09 with winds over 24 km/h (165 readings).

The number of tracks per day increased from June to a peak in mid-July (Figure 1). From this date forward the frequency dropped rapidly till the end of August. This decline was highly significant ($P < 0.01$, 2025 readings). Figure 1 shows the low frequency during the month of August and the first days of September, at which point we ceased observation for a week. Thus the activity of Moose in this study reflected the use of aquatics. We resumed observations on 9 September. There was still no sign of activity on the entire 16-km circuit until 10 September when

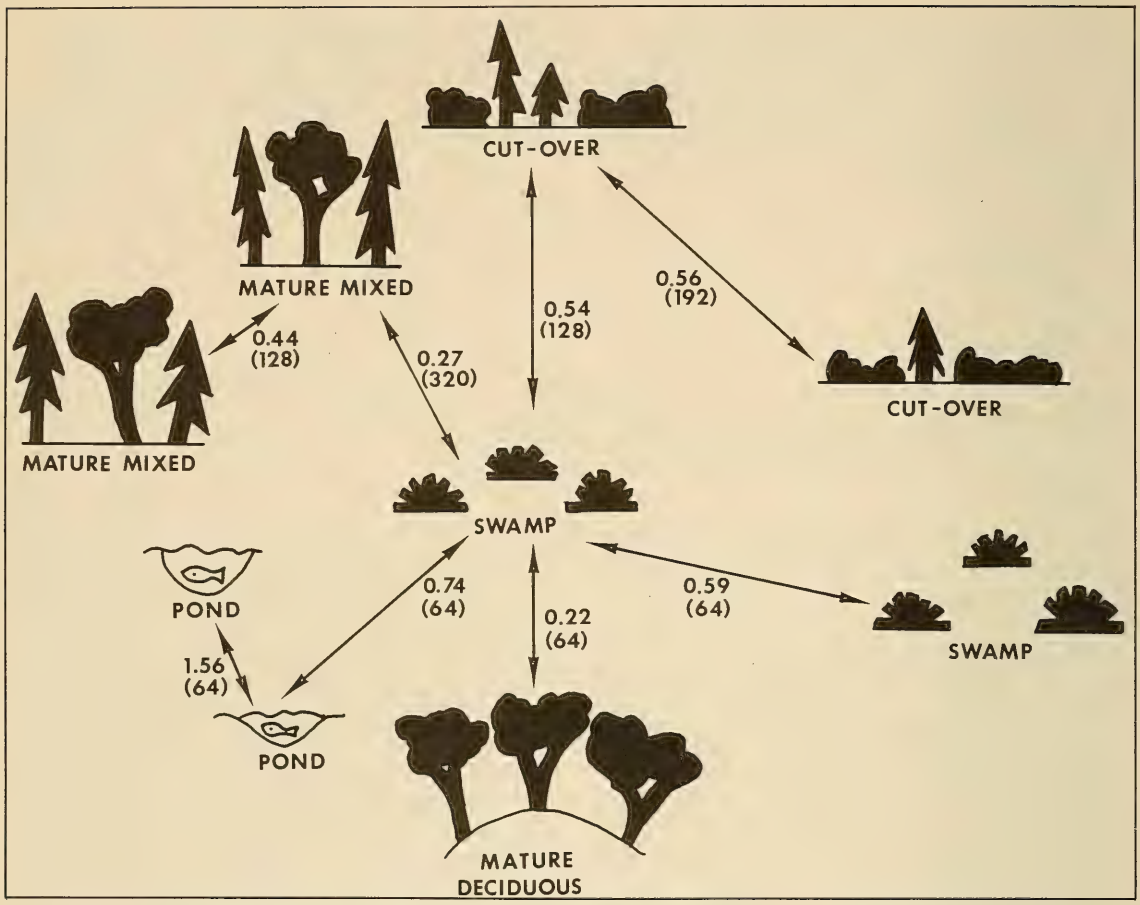

FIGURE 3. Movements between different habitats as indicated by the track index in Mont-Tremblant Park.

we noticed the tracks of two Moose. The road was ploughed up by hooves at two different places and the animals had faced each other, suggesting a bull fight.

Discussion

Knorre (1959) estimated that Moose were active 14 h per d in summer. Direct observations of Moose on land show that when active, they fed on shrubs and sometimes on forbs (McMillan 1954; Houston 1968). Limited direct observations on terrestrial activity confirmed these findings since we observed that Moose bedded for 4.5 h out of 13 h. Otherwise they wandered on the roads or in clear cuts, stripping leaves here and there while walking, or fed intensively on a clump of shrubs.

Since aquatic feeding lasted about 1 h and, exceptionally, betweent 2 and 3 h (Dunn 1976) we can ascertain that terrestrial feeding formed the bulk of the summer diet in dry weight. Our conclusion differs from that of Ritcey and Verbeek (1969) who believed that aquatic plants formed the bulk of the summer diet in Bowron Lake Park in British Columbia. Since grazing on herbs and forbs was limited, we think that within a summer habitat study program involving nutritive quality for ovulation rate improvement (Markgren 1969), the nutritive quality of shrub leaves should be studied first.

Moose use different shrub species in summer than in winter. Wintering Moose in La Vérendrye Park in western Quebec, showed quite a different order of choice, preferring willows most and White Birch least. Also, Mountain Maple was much utilized (Joyal 1976).

The track index suggested that aquatic habitat was an important element of summer Moose

range. Radiotelemetry studies in Mastigouche Provincial Park in Quebec (Raymond 1978) and in Maine (Dunn 1976) confirmed this observation. Furthermore, in Laurentides Park there are 2.3 times more road kills near ponds than anywhere else (Grenier 1974). This correlation was not related to salt concentration. Studies should be made to determine whether aquatics are important for Moose and why. For example, a trace element essential to the maintenance of Moose or affecting the reproduction rate could be found only in certain aquatics (see Jordan et al. 1973).

Most studies indicate that Moose are typically very active both at sunrise and sunset, and sometimes in the afternoon on hot humid days. The decline in aquatic feeding in a semi-wild area between 0600 and 0900 hours and a minimum of movement in a remote area between 1800 and 2100 hours were quite different in our study, as was the peak of aquatic feeding between 1200 and 1500 hours. Possibly the low level of early morning activity was due to disturbance from increased vehicular traffic on the nearby road (150 m away) as park employees went to work. Dunn (1976) observed that same peak of aquatic feeding between 1200 and 1400 in a semi-wild area.

In western Minnesota, Phillips et al. (1973) noted that a nocturnal peak in daily movement of Moose is typical. In Laurentides Park in Quebec, 83% of Moose road kills occurred at night and 75% between 2000 and 0300 hours (Grenier 1974). Our finding that 60% of movements were nocturnal was a minimum estimate since tracking at night is difficult in some conditions, such as rainy nights. In the eastern part of Minnesota, however, Van Ballenberghe and Peek (1971) noted nearly equal movement between night and day for a cow and its calf.

Our study confirms the observations of de Vos (1958) that aquatic feeding declined on rainy days. In the forest, however, Moose are probably less affected since neither rain nor wind has the same influence as in open areas like ponds and lakes.

Bouchard (1967) noted that Moose used aquatic habitats less often when winds were 11 to 18 km/h, whereas de Vos (1958) did not find any noticeable difference with wind up to 16 km/h. Since we found no statistical difference on movement with winds up to 24 km/h our results suggest then that wind has less influence on movement of Moose on the road than on aquatic feeding, confirming a decade of observation by the senior author.

The duration of mastication not only varied between sexes as we observed, but also between individuals, as results of Bouchard (1967) suggest. One could hardly generalize then on the evaluation of aquatic intake in a study of diet for energy or nutrient fulfillment. Sex will have to be considered and a large sample of both groups will be needed.

The length of time moose use aquatics appeared variable. In some parts of Ontario, the use of aquatic plants decreased gradually, beginning in August and ending in October (de Vos 1958). In Maine, ponds were also used until October although Dunn (1976) noted an abrupt decline in aquatic feeding in August. The behavior of our group of Moose, however, was similar to that studied by Bouchard (1967). In both cases there was a rapid decrease in the use of aquatics in early August ending entirely after mid-month. Observations during a Moose capture program on the lakes of Mastigouche Provincial Park in 1975 showed the same decline after the first half of August (Rivard 1977).

The complete and sudden disappearance of Moose during the second half of August either from water in 1972 or from the roads in 1973 suggests very strongly a temporary change in habitat-use patterns. But this would not explain why Moose would return to water in mid-September as reported by hunters. Decline in plant palatability cannot be the cause of the lack of aquatic feeding in August.

We believe that changes in habitat use are related to pre-rut activity. Many pre-rut activities were already observed during mid-August in Newfoundland 20 years ago (Dodds 1958). In Maine, Dunn (1976) noted an important increase in daily movement of radio-equipped Moose during August.

The bull fight is interesting because it suggests that by that time in western Quebec rutting behavior had started. According to bull harvest by hunting in all provincial parks, the rutting season, a period of greater vulnerability for bulls, would be earlier in western Quebec. Weather records for Mont-Tremblant Park

during the week previous to 10 September 1973, indicate minima of 2°, 13°, and 12°C and maxima around 22°C on 7, 8, and 9 September. Since the first frost of the year occurred on 15 September, the role of frost in initiating rutting activity seems unlikely.

Our conclusion is that July is the best time to study Moose behavior by direct (visual) or indirect (tracks) evidence. The best habitat would be composed of young or immature mixed forest with a water body nearby. Clear and windless days would be better for observation of Moose in water. Weather has less influence on Moose movements in the forest. This study suggests that movements are best studied at night.

Acknowledgments

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Asexual Reproduction, Diet, and Anomalies of the Anemone *Nematostella vectensis* in Nova Scotia

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Observed population increases in two aquaria containing the anemone, *Nematostella vectensis*, from Minas Basin, Nova Scotia were thought to be the result of asexual reproduction. This hypothesis was supported when 20 vitally stained and 10 unstained anemones produced 13 new individuals, 7 of which were stained. The enteron contents of 555 anemones revealed nine kinds of ingested items, *Hydrobia* and copepods being the most common. Several anomalous forms of the anemone were found but no one reason for the anomalies could be demonstrated.

Key Words: *Nematostella vectensis*, anemone, Nova Scotia, asexual reproduction, transverse fission, diet, anomalies.

Nematostella vectensis is a small rare anemone of the family Edwardsiidae, first described from the Isle of Wight. It has since been found in salt marshes in other localities in England, the Atlantic coast of North America, and the Pacific coast of the United States (Crowell 1946; Robson 1957; Hand 1957; Bailey and Bleakney 1966; Williams 1976). The English populations appear to be threatened with extinction, caused mainly by pollution and evaporation of their ponds (Williams 1976).

Over the last few years several papers have appeared dealing with *Nematostella vectensis* (Williams 1973a, b, 1975, 1976; Frank and Bleakney 1976) and a popular account has been written (Lindsay 1975). The purpose of this paper is to describe some further aspects of the asexual reproduction, diet, and anomalies of the anemone. Specifically, we hoped to show that *Nematostella vectensis* did in fact reproduce asexually and this could account for a rapid increase in the population. The diet of *N. vectensis* has not been reported previously. We also looked for anomalous forms of the anemone in field collections and laboratory experiments and compared them with those found by Williams (1975).

Methods and Materials

Anemones were collected from salt marsh pools at Kingsport, Nova Scotia and transported to the laboratory where they were kept at room temperature in two small aquaria. The aquaria had been prepared by providing a substrate of salt-marsh pool-bottom material (fine flocculent mud and plant detritus), as previous experience had shown that the anemones would not live long on clean glass-bottom containers.

Some of the anemones were stained with vital stains, Brilliant Cresyl Blue, Nile Blue A, and Safranin O, by injecting the stain into the enteron by hypodermic needle through the mouth. Usually two or three injections were needed to produce a color dark enough to be readily seen. The color persisted for about 2 wk.

To obtain direct evidence of asexual reproduction we placed 30 anemones in 10 finger bowls, each of which had mud and detritus on the bottom. Each bowl contained two vitally stained (one red and one blue) and one unstained anemone. The anemones were stained so that we could identify which anemones produced any fragments that might be found in the bowls. After the substrate had been added to the bowls, and before the experimental anemones were added, the bowls were left for 2 or 3 d and inspected regularly to make certain that any anemones inadvertently introduced with the bottom material were captured and removed. Therefore, any small anemones in excess of the three originally placed in a particular bowl would be the result of a reproductive process, and the sudden appearance of a stained fragment would strongly suggest asexual reproduction.

Diet items were determined by dissecting preserved anemones and analyzing the enteron contents.

Results

Asexual Reproduction

Collections had been made during October and November 1972, and every month in 1973 except February, March, and December prior to the experiment reported here. In many of these collections there were what appeared to be small pieces of anemones but lacking tentacles and pharynx. The pieces varied in size from 2 mm to 5 mm. It was suspected that these pieces might be the result of asexual reproduction.

Anemones kept in two aquaria were counted every day and several times there were more anemones than had been counted the previous day. Almost all of the new anemones were identified and all appeared to be pieces similar to those found in the field collections. After 3 wk, all of the anemones that could be seen in the two aquaria were removed and in both cases more anemones were taken out than had been put in. From one aquarium, to which only 20 anemones had been added, 29 were removed; and from the other which started with 18 anemones, 39 were removed.

It seemed evident that the new anemones were the result of asexual reproduction but, to go beyond circumstantial evidence 10 finger bowls were set up, with 30 anemones 10 to 20 mm long, as described. Fragments began to appear within the first few days but they were all unstained, so the possibility that anemones had been buried in the mud could not be completely ruled out. After 17 d, on 27 September, however, a red fragment was found in one of the bowls, and more colored fragments were found up to the end of the experiment. From 10 September to 15 October, 13 fragments were produced by the 30 anemones, and 7 of these were stained. Most of them were 3 to 5 mm long, and the same diameter as the parent anemones. The fragments all produced tentacles and a pharynx within about 2 d, thus conclusively showing asexual reproduction of *N. vectensis*. The actual process was not witnessed and in every case took place at night.

Diet

Two hundred forty-two anemones collected in 1965, 1966, and 1971 were dissected by Joan McCracken and the enteron contents were examined (unpublished report, Acadia University). Of these, 32 contained 42 items: 21 *Hydrobia* snails, 18 chironomid larvae, and 3 corixid adults, suggesting that insect adults or larvae make up a substantial part of the anemones' diet.

In the present study, 313 anemones were dissected with somewhat different results. In the 74 with enteron contents, there were 114 items of eight categories, including 15 *Hydrobia* snails, 13 ostracods, 40 copepods, 2 chironomid larvae, 11 "worms," 18 egg masses, 14 unidentifiable animals (mostly crustaceans), and what appeared to be 1 rotifer test. Most of the "worms" were nematodes; however, some were polychaetes; the egg masses were probably from copepods. Although it is possible that some of these items were ingested accidentally, almost all of them showed signs of digestion and there were sufficient quantities of most of them in the anemones dissected to consider them regular prey. These data are summarized in Table 1.

Nematostella vectensis in the Minas Basin were usually found in pools with most of the column buried but also occurred stretched out on the bottom or floating in surface algae. They "hunted" by stretching out the tentacles until something made contact. Although usually stationary, they would sometimes tip the body in different directions or appear to explore the surroundings with several tentacles.

The tentacles of *N. vectensis* are extremely responsive to tactile stimulation and immediately wrap around anything that touches them, including metal probes, and draw these objects toward the mouth. This process was observed with a chironomid pupa which was placed on the tentacles of an anemone in the laboratory. The pupa was captured and drawn to the anemone's mouth, but it took 2 h 40 min before ingestion was completed. Digestion involved another 23 h, after which the exoskeleton was ejected.

Anomalies

Several aberrant forms of *N. vectensis*, such as double-headed anemones and forked tentacles, have been discussed by Williams (1975) for anemones found in England. Similar forms were found in the Minas Basin. The double-headed anemones (having a tentacled oral region at both ends of the body column) were more common in the late summer and fall, which is similar to Williams' findings in England (personal communication). Of nearly 1300 anemones collected from the Minas Basin in 1972 and 1973, 17 had

TABLE 1—Food items from enteron of *Nematostella vectensis*. Collections were not available for February, March, and December. The bracketed figures are from Joan McCracken's unpublished report

Month	*Hydrobia*	Copepods	Chironomid larvae	Egg masses	Unidentified	Ostracods	"Worms"	Corixids	Rotifer	No. of anemones examined	Subtotal
January	0	0	0	0	0	0	0	0	0	12(8)	20
May	0	1	0	5	0	2	0	0	0	18(0)	18
June	11	2	0	3	3	0	1	0	1	81(0)	81
July	3(5)	0	0	1	3	0	0	0(1)	0	20(27)	47
August	9	29	1	7	7	0	5	0	0	59(14)	63
September	3	12	0	0	3	12	6	0	0	78(0)	78
October	2(15)	2	1(16)	0	0	0	0	0(2)	0	27(123)	150
November	0(1)	0	0(2)	0	0	0	0	0	0	18(70)	88
Subtotal	28 (21)	46 (0)	2 (18)	16 (0)	16 (0)	14 (0)	12 (0)	0 (3)	1 (0)	313 (242)	
Total	49	46	20	16	16	14	12	3	1	555	

tentacles and pharynx at both ends of the body column, with sizes ranging from about 1 mm to 47 mm. One Y-shaped anemone, with two adjacent tentacle crowns and one physa, was collected, and several anemones with forked tentacles were also found. Anemones, such as Williams' (1975), found lacking tentacles or with a single tentacle crown and two opposing oral cones were not observed in the Minas Basin population.

Several of the apparently normal anemones kept in an aquarium developed a second oral cone and tentacles at the physa end, and one double anemone placed in an aquarium resorbed one tentacle crown and developed a normal physa.

Figure 1 shows an anemone that is just developing a second tentacle crown; the second set of tentacles is still quite small. In all other double anemones found, the tentacles at both ends of the column were of approximately equal sizes. Also note in Figure 1 that the larger tentacle crown is composed of 20 tentacles, the largest number recorded for *N. vectensis*. Previously, the maximum number reported was 18 (Stephenson 1935).

Discussion

Lindsay (1975) described the transverse fission process for *N. vectensis* as beginning with elongation of the parent, followed by the development of a transverse constriction in the posterior portion of the column. About 24 h later, a new individual was formed, and tentacles were produced after about 2 d. Although the process was not actually witnessed during the present study, the fragmented pieces did develop tentacles and a pharynx within 2 d. The anemones in the bowls were inspected frequently throughout the day but persistent constrictions, as described by Lindsay, were not observed. Apparently in our study, the complete process took less than 24 h; in fact, the longest period the anemones went unobserved, excluding most weekends, was about 14 h.

Asexual reproduction undoubtedly plays a major part in the population dynamics of *N. vectensis* in the Minas Basin. To date, evidence of sexual reproduction has been reported only in the late summer and fall (Frank and Bleakney 1976), but collections from pools in early spring and into the summer frequently contained small anemones and fragments, the latter identical to those produced in the laboratory. Williams (1976) observed transverse fission in January 1975 and speculated that the process might continue through the year. It is certainly probable that asexual reproduction by fission is responsible for the general increase in the population during the spring and early summer months.

Nematostella vectensis is unique in that it is

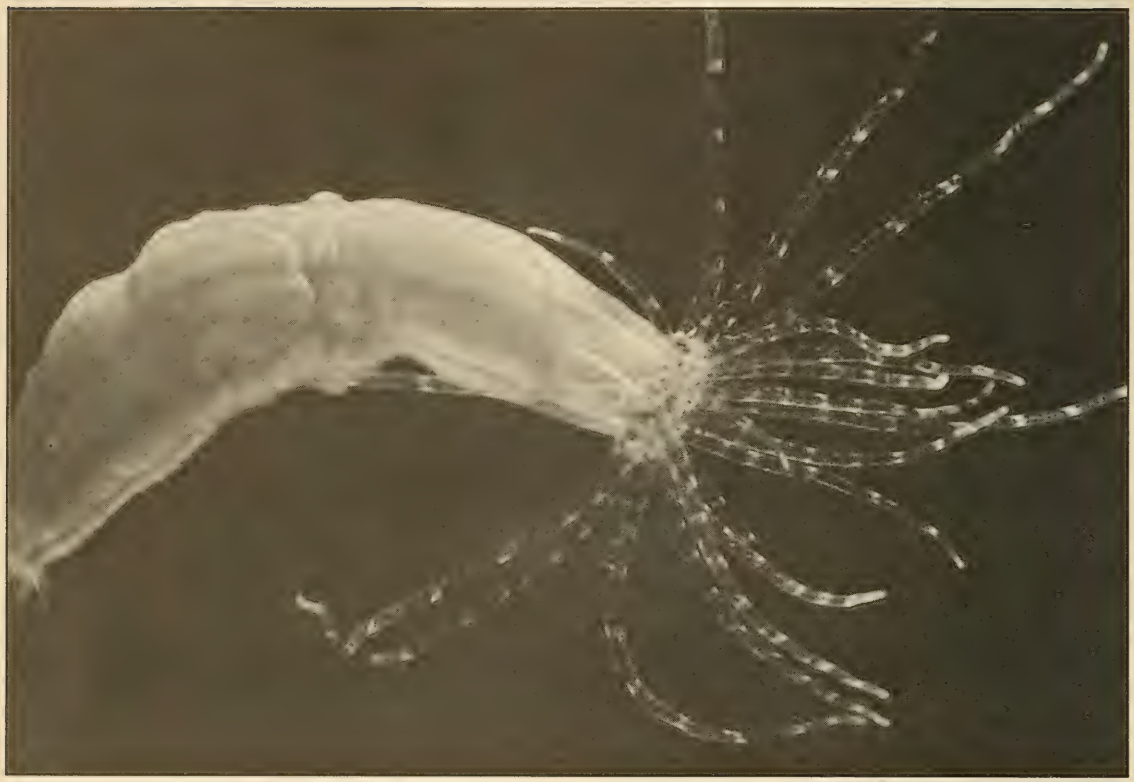

FIGURE 1. *Nematostella vectensis* from Minas Basin, Nova Scotia. Note the tentacle buds in addition to the 20 full-sized tentacles.

the only anemone known to feed on insects. Minas Basin anemones fed on chironomid larvae and corixids, and Lindsay (1975) also reported them feeding on midge larvae. Anemones in Half-Moon Pond, Norfolk, England feed on the larvae of *Chironomus salinarius* and on harpacticoid copepods (Williams 1976). Insects, however, did not make up a sizeable portion of the anemones' diet in the Minas Basin, even though chironomids were especially abundant. The major prey were *Hydrobia minuta* and copepods (Table 1) which were also the most abundant animals in the pools. This is what one would expect for an animal that is basically sessile and opportunistic and that cannot actively pursue its prey.

Anemones collected in 1972 and 1973 had not ingested numbers of chironomids and corixids comparable to the numbers taken in the earlier collections of anemones. This is not really surprising since chironomids and corixids are comparatively large active animals and when they came in contact with a tentacle they were usually observed to break away easily. *Hydrobia* are also large but they are relatively slow, and their reaction to attack may be simply to withdraw into their shell and thus give the anemone an opportunity to ingest them without any trouble.

Anemones examined from 1965, 1966, and 1971 apparently did not ingest any of the smaller animals such as copepods. They are often difficult to distinguish in dissected anemones, however, and it is possible that these smaller food items were present but were overlooked.

No explanation could be found for the anomalous anemones. Williams (1975) suggested three possibilities: imperfect asexual fission, regeneration of a damaged animal, or a genetic defect in the zygote. All of these possibilities are reasonable, but as yet, no evidence has been found to single out any of

them. It is worth noting, however, that in our aquaria none of the anemones that eventually developed a second set of tentacles appeared to be damaged. Whatever the reason, the transformation from normal to double anemone can be quite rapid. Our anemones developed second oral regions, complete with pharnyx and tentacles only slightly shorter than normal in about 2 d. Only one anemone collected from the marsh (Figure 1) appeared to be in the process of developing a second oral end, and its second set of tentacles was considerably smaller than the original set.

Acknowledgments

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Changes in the Aquatic Macrophyte Flora of Whitewater Lake near Sudbury, Ontario from 1947 to 1977

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Dale, H. M. and G. E. Miller. 1978. Changes in the aquatic macrophyte flora of Whitewater Lake near Sudbury, Ontario from 1947 to 1977. Canadian Field-Naturalist 92(3): 264–270.

The 1977 aquatic flora of Whitewater lake, near Sudbury, Ontario, was compared with that recorded 30 yr ago before the recent release of municipal and industrial effluents into the lake. The abundance of each species in the flora was rated by estimating the cover contributed at each of 23 sites visited. Water Star Grass (*Heteranthera dubia*) and Pickerel Weed (*Pontederia cordata*) had increased in abundance whereas several species from the earlier survey, including Wild Rice (*Zizania aquatica*), Lesser Duckweed (*Lemna minor*), Floating Heart (*Nymphoides cordatum*), and Water Marigold (*Megalodonta beckii*), were not seen and seven other species showed a very marked decrease in abundance. Six species, including four pondweeds (*Potamongeton amplifolius, P. gramineus, P. natans,* and *P. praelongus*), Water Crowfoot (*Ranunculus trichophyllus*), and the North American Water Milfoil (*Myriophyllum exalbescens*) that reacted to disturbance by decrease in abundance or by apparent disappearance, could be classed as indicator species.

Key Words: aquatic, macrophyte, population, change, water quality, indicator species.

At a time when there is interest in changes in the aquatic plant life in our lakes, particularly overgrowths of certain species, there is a scarcity of data against which changes can be assessed. Original surveys of lakes listed the species then present but often omitted any estimates of their abundance, and so quantitative comparisons cannot be made.

Lake East Okoboji, Iowa, surveyed in 1915, showed, in a re-survey in 1961, a reduction from the original 26 submersed and floating species to 7 species (Volker and Smith 1965). Five abundance categories from "Very abundant or Dominant" to "Less frequent" were based on presence or absence of species at 21 stations visited in a small boat. The authors attributed the changes in the flora to pollution by sewage and agricultural fertilizer, as well as to other factors.

University Bay, Lake Mendota, Wisconsin, has been the subject of many surveys over the years. Lind and Cottam (1969) assessed the plants by running 21 transect lines from shore to deep water and noting the plants that intercepted these lines over 0.5-m segments. Their figures were used to obtain relative frequency figures for each species. These were compared with dry-weight estimates made in 1922. They found that several submersed and floating species, which had been major components of the vegetation in 1922, had completely disappeared, while there was a decrease in Wild Celery (*Vallisneria americana*) and a marked increase in Water Milfoil (*Myriophyllum exalbescens*). Further, they claimed that University Bay had reached its ultimate stage of eutrophication, using abundance of indicator plants as a measure.

Harman and Doane (1970) examined the change in aquatic flora between 1935 and 1969 in Otsego Lake, New York. They recorded subjective abundance figures obtained by hand-picking in shallow water while wading and, in deeper water, by using a boat hook (following the methods of Muenscher 1936) and diving. Five new submersed and floating species were found including the European *Potamogeton crispus* which had become a dominant member of the flora. Many species had decreased in abundance and 12 that were on Muenscher's list of 1936 were not found, indicating the increase in nutrients with increasing population in New York State during a 34-yr interval (Harman and Doane 1970).

In the Finnish Lake District, Kurimo (1970) lists seven categories of aquatic macrophytes by their tolerance to pollution in water, ranging from species which benefit from wastes in the water, through indifferent species, to those which shun contaminated waters. She also

differentiates among several types of waste water including domestic sewage, industrial chemicals, and wood fibres.

The changes in a bay at South Bay Island, Lake Erie, from the flora of 1898 have been described by Stuckey (1971). He dredged plants from the bottom with a grappling hook and based abundance ratings on the number of times a species was caught in the hook, plus evidence from herbarium records. He found that half of the original flora had disappeared and the abundances of the remaining species had changed considerably. Four new submersed species were encountered. Suggested factors influencing these changes include increased water temperature, decrease in oxygen levels, increase in turbidity, dumping of domestic sewage, and runoff from agricultural lands.

Our 1977 study examined the plants in Whitewater Lake to determine the changes that have taken place in the submersed and floating aquatic flora over a period of enrichment and disturbance. Early records of aquatic plants in the lake include the successful introduction of Wild Celery for waterfowl food (Mickle and Thompson 1913) and a survey to assess the potential of the lake for supporting waterfowl populations by J.H. Soper[1] in 1947. During the latter survey a description of the aquatic flora and notes on the abundance of species were recorded. The changes found 30 yr after the survey of 1947 are described in this report.

Study Area

Whitewater Lake, 46°32′N, 81°08′W, is 7 km long and varies in width from 0.4 km to 3 km. The surface area of the lake is approximately 9 km^2 and the shoreline, excluding islands, runs for 25 km. There are five streams entering the lake from the south and three through the built-up area along the northern shore. The lake drains from the extreme western end to Levery Creek which joins the Vermillion River several miles to the west. Since 1976 the water level has been controlled by a dam on Levery Creek. The lake is naturally divided into eastern and western halves by a strait. The eastern basin is shallow throughout, never exceeding 3 m, while the western basin is much deeper, exceeding 10 m in some places[1]. Much of the shoreline is rocky, especially along the northern shore of the western basin. But, the substrate throughout the lake is very fine and rich in clay. Consequently, strong wave action makes the water noticeably cloudy by churning up the bottom.

The village of Azilda, one of the centers forming the Town of Rayside-Balfour, is located on the northern shore of the eastern basin of the lake. Its population was about 4000 in 1977, while 30 yr ago the area was occupied by farmland (Ruberge, personal communication). During the rapid expansion of the village no sewers were constructed. Domestic waste was treated in individual septic systems and a series of ditches removed runoff. It was evident from algal blooms that nutrient enrichment was occurring in the three streams flowing through Azilda. In 1976, when the population was about 3500, sewage disposal systems were installed. The effluent now receives secondary treatment and discharges into the Whitson River which does not enter Whitewater Lake. Recently installed storm sewers, however, do drain into the lake. In 1977 swimming was forbidden in areas of the lake at the town site by the Regional Department of Health. The extensive mining operation to the south-east in the Sudbury – Copper Cliff region has also had some influence. Gaseous sulphur dioxide discharged from various stacks does not affect Whitewater Lake directly. The tailings dams, however, are situated on the Whitewater watershed. The chief drainage for the tailings dump is towards the south but some runoff flows into Pump Lake and Clara Belle Lake which drain into Whitewater. The effluent that runs south of these tailings is high in copper, nickel, and iron and has a pH of 7.8 (Schabas 1977).

Methods

In late June and early July 1977, the aquatic flora was surveyed at 23 sites selected to include the different habitats around the lake (Figure 1). These consisted of three deep-water sites (13, 17, 23) where only vegetation in water of > 2 m (within 5 m of the boat) was surveyed; 19 where all aquatic plants present were recorded from the

[1]Soper, J. H. 1948. A survey of the aquatic vegetation of Whitewater Lake, with special reference to its suitability to waterfowl. A report prepared for the Department of Lands and Forests of Ontario, Toronto. 13 pp. mimeo.

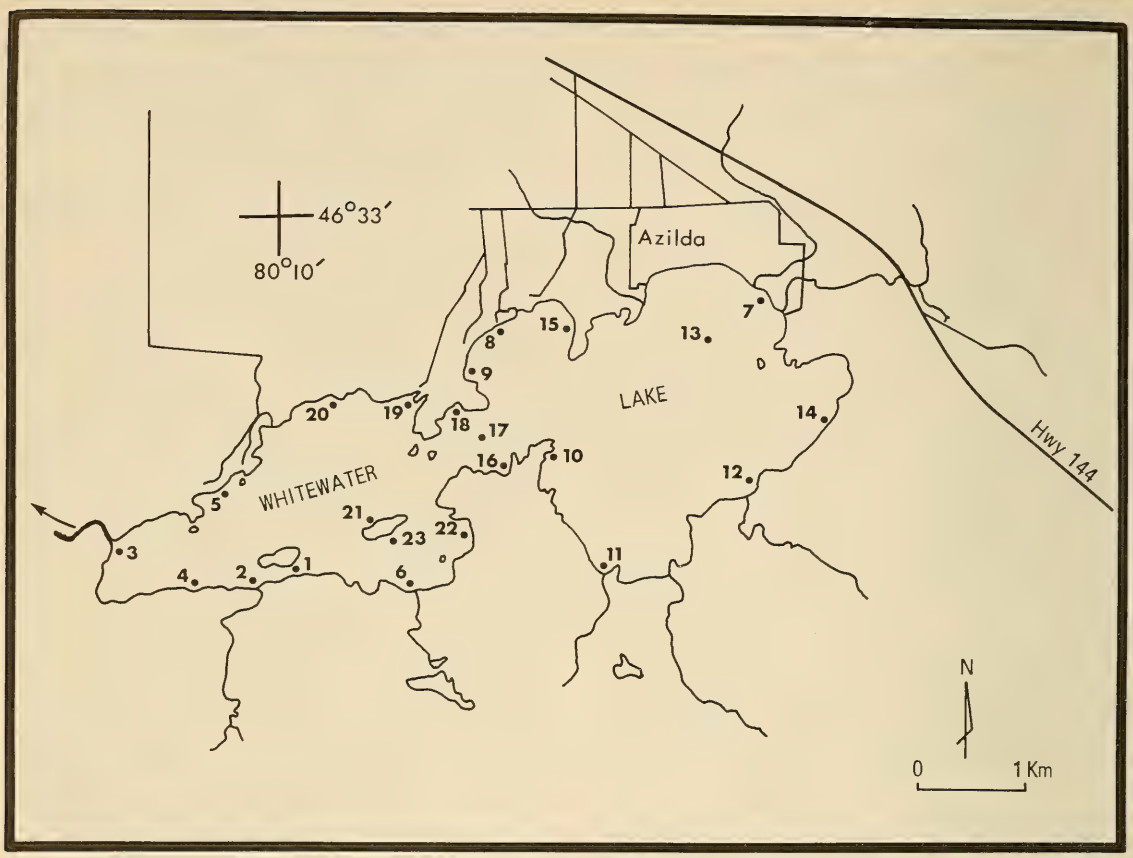

FIGURE 1. Location of the 23 sites sampled for aquatic macrophytes in Whitewater Lake, Ontario. The lake is situated on the north-west boundary of Sudbury, Ontario.

shoreline to a depth of 2 m of water; and one site (7) was examined on the stretch of shoreline where swimming was prohibited. This last was also recorded as a special case; at the other 19 sites, a diver observed and recorded all species present within 20 m of the boat. Each species was given a cover rating related to its percentage cover: > 50% — 16; 25–50% — 9; 10–25% — 4; < 10% — 1. The sum of the cover ratings for a species at all sites then gave abundance numbers for that species. Ordering of the abundance numbers revealed natural breaks. Those species with lowest numbers were called rare and those with highest numbers abundant. By using these terms, comparison of the data was possible with the descriptive ratings used by Soper[1].

Water samples were collected from sites 8, 13, and 22 and analyzed for conductivity and alkalinity. Specific conductivity was measured on a Barnstead conductivity bridge, model 70CB. The cell was of a dip type (Fisher Scientific Model 3417) with a casing of ABS plastic and a cell constant of 1.

Alkalinity was determined by titration with 0.02 N H_2SO_4 to a methyl purple end point (pH 4). The total volume titrated times 10 gave the total alkalinity as mg $CaCO_3 \cdot L^{-1}$ (Wood 1975).

Results

The readings in conductivity (173–176 μmhos$\cdot$cm^{-1}) and alkalinity (22–26 mg $CaCO_3 \cdot L^{-1}$) at the three sites indicate no differences. The small variations are within the error of the methods of measurement.

Table 1 gives the frequency and abundance figures for the 27 submersed and floating species present in Whitewater Lake. The species are thus placed in one of the four groups using the abundance terms of the earlier survey[1]. Table 2

TABLE 1—Frequency and abundance of floating and submersed species from 22 sites in Whitewater Lake

Species*	Frequency	Abundance
Abundant		
Clasping-leaf Pondweed (*Potamogeton richardsonii*)	21	193
Needle Rush (*Eleocharis acicularis*)	15	164
Water Star Grass (*Heteranthera dubia*)	17	141
Quillwort (*Isoetes braunii*)	13	137
Bushy Pondweed (*Najas flexilis*)	12	120
Common		
Wild Celery (*Vallisneria americana*)	13	83
Pickerel Weed (*Pontederia chordata*)	13	75
Sago Pondweed (*Potamogeton pectinatus*)	12	75
Water Moss (*Drepanocladus aduncus*)	9	74
Yellow Water Lily (*Nuphar variegatum*)	11	61
Small Water Milfoil (*Myriophyllum alterniflorum*)	11	56
Occasional		
Floating-leaf Arrowhead (*Sagittaria cuneata*)	8	42
Manna Grass (*Glyceria borealis*)	7	35
Floating-leaf Bur Reed (*Sparganium angustifolium*)	4	28
Variable Pondweed (*Potamogeton gramineus*)	2	25
Myriophyllum tenellum	3	24
Rare		
Small Yellow Water Lily (*Nuphar microphyllum*)	4	15
Floating-leaf Pondweed (*Potamogeton natans*)	3	12
Narrow-leafed Pondweed (*Potamogeton berchtoldii*)	5	11
Whitestem Pondweed (*Potamogeton praelongus*)	2	10
Water Crowfoot (*Ranunculus trichophyllus*)	2	10
White Water Lily (*Nymphaea odorata*)	1	9
Large-leaf Pondweed (*Potamogeton amplifolius*)	2	8
Pipewort (*Eriocaulon septangulare*)	3	6
Water Milfoil (*Myriophyllum exalbescens*)	2	2
Potamogeton filiformis	1	1

*Common names from Fasset (1957).
NOTE: See Soper[1] for authorities for Latin names.

compares the ratings of the 1947 and 1977 surveys. Six of the 30 taxa found in the earlier study were not found in this study; but there were five additional species.

Of the absent taxa, *Nuphar rubrodiscum* was not identified as present in the lake but several vegetative plants with leaves intermediate between *N. microphyllum* and *N. variegatum* were noted. It is likely that *N. rubrodiscum* could still be identified as a hybrid between the other two species. In this study the intermediate forms were grouped into one or the other of *N. microphyllum* and *N. variegatum* depending on leaf size. Wild Rice (*Zizania aquatica*) and Lesser Duckweed (*Lemna minor*), rare in 1947, could not be found in 1977. Similarly, Floating Heart (*Nymphoides cordatum*) and Water Marigold (*Megalodonta beckii*) had been rated as abundant in 1947 but were not found in 1977. Since the authors are familiar with these species and were specially attentive in searching for them, they must now be considered extremely rare or extinct in Whitewater Lake. *Potamogeton pusillus* L. was probably the deep-water pondweed that we identified as *P. berchtoldii* Fieber. It is present although its abundance has decreased significantly. An examination of the records for *P. foliosus* in the 1947 study show it to be more abundant than indicated in Table 2. But the collections of some narrow-leafed pondweeds numbered 3584, 3585, 3623, and 3567 were all annotated by Soper on 12 April 1957 and called *P. pusillus*: B. Boivin and André Bouchard confirmed these identifications in 1970. The single remaining sheet of *P. pusillus* has no data on abundance. We have rated it as rare in 1947. We have also taken the liberty of changing the name of sheet 3549 from Floating-leaf Bur Reed (*Sparganium fluctuans*) to *S. angustifolium* to agree with the nomen-

TABLE 2—A comparison of the submersed and floating species of aquatic macrophytes in Whitewater Lake in 1947 and 1977

Species list (Soper[1])	1947 Abundance	1977 Abundance
Water Moss	Common	Common
Quillwort	Fairly common	Abundant
Floating-leaf Bur Reed	Common	Occasional
Bushy Pondweed	Common	Abundant
Large-leaf Pondweed	Common	Rare
Potamogeton foliosus	Rare	*
Variable Pondweed	Abundant	Occasional
Floating-leaf Pondweed	Abundant	Rare
Sago Pondweed	Abundant	Common
Whitestem Pondweed	Abundant (locally)	Rare
P. pusillus	Abundant (deep water)	*
Clasping-leaf Pondweed	Most abundant	Abundant
Floating-leafed Arrowhead	Occasional	Occasional
Wild Celery	Abundant	Common
Manna Grass	Common (locally)	Occasional
Wild Rice (*Zizania aquatica*)	Rare	*
Lesser Duckweed (*Lemna minor*)	Rare	*
Pipewort	Fairly common	Rare
Pickerel Weed	Occasional	Common
Water Star Grass	Rare	Abundant
White Water Lily	Occasional	Rare
Small Yellow Water Lily	Occasional	Rare
Yellow Water Lily (*Nuphar rubrodiscum*)	Very common	See text [1]
Yellow Water Lily (*Nuphar variegatum*)	Abundant	Common
Water Crowfoot	Common	Rare
Small Water Crowfoot	Occasional	Common
Water Milfoil	Common	Rare
Floating Heart (*Nymphoides cordatum*)	Abundant	*
Water Marigold (*Megalodonta beckii*)	Abundant	*
Species found only in the 1977 survey:		
Potamogeton filiformis		Rare
Needle Rush		Abundant
Myriophyllum tenellum		Occasional
Narrow-leafed Pondweed		Rare

*Not found.

clature of Voss (1972).

Needle-rush (*Eleocharis acicularis*) was abundant and the very small *Myriophyllum tenellum* was common, but a careful examination using a face mask was necessary to distinguish these and Pipewort (*Eriocaulon septangulare*) in situ. The Narrow-leafed Pondweed (*Potamogeton filiformis*) was represented by one plant. It may have been a rare element of the flora which was not previously found.

In summary, it is unlikely that there have been any additions to the Whitewater Lake submersed and floating flora in the last 30 yr. Five taxa can, however, be considered extinct. Four of these were common or abundant in 1947.

Discussion

Although the water chemistry seems uniform throughout the lake, the ratio of alkalinity to conductivity is too low to be consistent with the pattern in Ontario (Miller 1977). Electrical conductivity is influenced by the alkalinity of the water but it can also be affected by other ions. The concentrations of these other electrolytes in Whitewater Lake are higher than in most other lakes and could be the result of metal salts from the mine tailings, nutrients from municipal sewage, sodium chloride from road salt or, more likely, a combination of all of the above.

The previous study of Whitewater plants was chiefly from the surface of the water without reference to specific sites or quantitative

abundance. In this study, an estimate of the abundance of each species over the whole lake was found by summing the cover ratings. The cover ratings are given greater prominence by the expedience of using the number scale of 1:4:9:16. This simple approach has some advantages over those used in comparable studies (Harman and Doane 1970; Lind and Cottam 1969; Stuckey 1971). It combines the general distribution over the lake by using the site frequency with the quantity of the species at each site. The original survey by Soper[1] did not warrant the sophistication of quadrat studies.

Table 3 summarizes those species with the largest changes in abundance ratings. Five extinctions are indicated in the fourth column of Table 3 by the letter E; seven species decreased in abundance shown by D; two increased. The same symbols are used in Table 3 for the four other studies cited above. Not all studies refer to all species in the table. For the species common to Whitewater Lake and any of the other four study areas the following consistently decreased in abundance or became extinct: the pondweeds (*Potamogeton amplifolius*, *P. gramineus*, *P. natans*, and *P. praelongus*), Wild Rice (*Zizania aquatica*), Water Crowfoot (*Ranunculus trichophyllus*), and Water Marigold (*Megalodonta beckii*). For other species the situation is not as clear, as it is possible that a maximum development of such species as Water Milfoil and Water Star Grass (*Heteranthera dubia*), is favored by a certain degree or type of pollution.

Water Star Grass significantly increased in abundance over the 30-yr period. The same change was observed in University Bay (Lind and Cottam 1969). With a number of extinctions and reductions in abundance occurring it would be expected that those species with broader tolerance limits would increase their numbers as a response to the reduction in competition. In the case of Water Star Grass, it has expanded from a rare element of the shallow-water vegetation to the dominant species in the deeper water of the lake. In other types of water, in other studies, the same species decreased in abundance in Lake Erie (Stuckey 1971), became extinct in the Iowa lake (Volker and Smith 1965), and retained its abundance in the New York lake (Harman and Doane 1970).

The emergence of a pattern in the success of various species in a polluted or disturbed environment suggests the use of these species as indicator organisms. The species on the list appear to be sensitive to the changes in water quality. But there are other qualities necessary for a useful indicator species. An indicator species must also be widely distributed, fairly abundant when it occurs, and must be easy to identify. A complication that occurs with regard to distribution of aquatic plants is that different glacial and geologic histories of certain areas

TABLE 3—Changes in abundance ratings of species between 1947 and 1977 in Whitewater Lake and a comparison with published records. The abundance ratings are rare (R), occasional (O), common (C), and abundant (A). The other symbols refer to the increase (I) or decrease (D) in abundance of a species over time or its extinction (E). An asterisk denotes those species which may be useful as indicators

	Abundance		Change in abundance				
Species	1947	1977	Dale and Miller 1977	Volker and Smith 1965	Lind and Cottam 1969	Harman and Doane 1970	Stuckey 1971
Large-leaf Pondweed*	C	R	D	E	E	D	E
Potamogeton foliosus	R	—	E	I		E	E
Variable Pondweed*	A	O	D	E		D	E
Floating-leaf Pondweed*	A	R	D	E		D	E
Whitestem Pondweed*	A	R	D	E		D	E
Potamogeton pusillus or *berchtoldii*	A	O	D	E		same	E
Wild Rice	R	—	E			E	
Lesser Duckweed	R	—	E	I		same	
Water Star Grass	R	A	I	E	I	same	D
Water Crowfoot*	C	R	D	E	D	D[1]	
Water Milfoil*	C	R	D		I	D	
Floating Heart	A	—	E				
Water Marigold	A	—	E	E		D	E

[1]Called *R. aquatilis*.

give rise to a wide variety of lake water qualities. Within Ontario there are definable macrophyte floras occupying the lakes with the range of water chemistry present. These floras combine to form five identifiable lake types in Ontario, each possessing a characteristic combination of species (Miller 1977). A species can be useful as an indicator only in the lake types in which it normally occurs. The species indicated by an asterisk in Table 3 are positive indicators of a healthy or undisturbed environment. If they are currently absent from an area and old records of their past existence are available, it may be concluded that the environment has changed. An indication of an already disturbed ecosystem may be provided by those species which increase their abundance with disturbance.

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Porcupine Winter Foods and Utilization in Central New Brunswick

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Speer, R.J. and T.G. Dilworth. 1978. Porcupine winter food and habitat utilization in central New Brunswick. Canadian Field-Naturalist 92(3): 271–274.

Wintering areas and winter foods utilized by Porcupines (*Erethizon dorsatum*) were studied in central New Brunswick during 1973–74 and 1974–75. Sixty-nine dens and 18 roost trees were found on the 800-ha study area. Wintering areas were on more moist soil sites, nearer to a permanent water supply, had slightly smaller-diameter trees, and the percentage basal area made up by conifers was greater than on randomly selected areas. When feeding on bark, Porcupines showed a preference for spruce, White Pine, Eastern Larch, and Gray Birch. Ninety-one percent of the bark-feeding was on conifers. Bark-feeding on Eastern Larch occurred predominantly in spring and fall. Every tree species that made up more than 0.5% of the trees in the plots was utilized. When feeding on twigs, Porcupines showed a preference for White Cedar. Feeding occurred on 3% of the trees in the wintering areas compared to 0.13% in the randomly selected control plots. Forest management implications are discussed.

Key Words: Porcupine, food habits, habitat, food preference.

The Porcupine (*Erethizon dorsatum*) occurs in most forested areas of Canada and feeds on a variety of herbaceous plants and trees (Banfield 1974, pp. 233–236). Its feeding on bark of trees can cause damage in forests managed for maximum wood production. For example, Tidswell (1975) reported 13% of the European Larch (*Larix decidua*) in an experimental plantation in central New Brunswick killed in one year.

This study was initiated to gather ecological information on the Porcupine, as a prerequisite for developing an effective damage-control program where needed. It compares winter habitat used by Porcupines with habitat available in the area, and reports food utilized during the winter.

The 800-ha study area (45°51′N, 66°22′W) was located on the Acadia Forest Experimental Station, of the Canadian Forestry Service, 25 km east of Fredericton, New Brunswick. Topography is flat with elevations between 40 and 60 m. Heavy basal till overlays flat carboniferous sandstone and mudstone bedrocks and allows little internal drainage (Loucks 1959–60). There are few rocks and no rock cavities. Raised peat bogs are common.

The area is within the Maritime Lowlands Ecoregion (Loucks 1959–60). Principal tree species are Black Spruce (*Picea mariana*), Red Spruce (*Picea rubens*), Balsam Fir (*Abies balsamea*), White Pine (*Pinus strobus*), Red Maple (*Acer rubrum*), and Gray Birch (*Betula populifolia*). Experimental plantations of European Larch, Scots Pine (*Pinus sylvestris*), and Red Pine (*Pinus resinosa*) are present. A more complete description of the area may be found in Thomson (1955).

Methods

We located Porcupines by walking transects 100 m apart watching for signs in the snow. The entire study area was searched 2 or 3 times each winter during December and January and sections that were found to be used regularly were searched at 2-wk intervals.

During this field work, efforts were made to locate Porcupine dens and "station trees" (Curtis and Kozicky 1944) or "roost trees" (Tidswell 1975). Areas that offered some shelter and contained scats indicated dens, whereas scats on the ground, a strong urine odor, and claw marks on the tree trunk indicated a roost tree.

At 22 den or roost-tree sites during 1973–74 winter, 30-m-radius circles were laid out with the den or roost trees as the center. The 30-m radius was selected since this encompassed more than 90% of all feeding around the dens or roost trees. The area within the circle was assumed to be the wintering area. For comparison, 20 control points were randomly selected and plots laid out around them.

On each plot, average soil moisture was estimated on a scale of 1–10 where 1 was

completely dry and 10 was open water. Density of shrub layer was assessed on a scale of 1–5 with 1 being no underbrush and 5 a continuous dense layer. Crown closure was recorded on a scale of 1–3 where 1 was open and 3 was thick. Slope, aspect, distance to a permanent water supply, and distance to nearest potential den site were also recorded.

For each tree over 6 cm diameter at breast height the species, diameter, distance to the nearest neighbor (Clark and Evans 1954), area of wood exposed by bark feeding, and amount of twig feeding (i.e., feeding on needles and new shoots) were recorded. The amount of twig feeding was estimated as 1, no feeding; 2, light feeding (claw marks on trunk and twigs on the ground); or 3, heavy feeding evident by marked defoliation. The distance from each tree used as feed to the plot center was recorded.

The data were tested using the Mann-Whitney U-test (Zar 1974, p. 109) and the two-tailed *t*-test. The percentage basal area made up by conifers was transformed using an arcsine transformation (Zar 1974, p. 195) before testing.

Results and Discussion

Sixty-nine dens (1 per 12 ha) were located. Of these dens, one was a hollow Red Maple snag, three were under snowladen branches of Balsam Fir, and 65 under the roots of partially windthrown trees. Eighteen roost trees were found; all were large dense-crowned conifers. Curtis and Kozicky (1944) found that Porcupines used the same type of dens and station or roost trees in Maine.

Dens and roost trees were used by a number of individual Porcupines during each winter period, but rarely by more than one at any one time. These observations support the notion of the solitary nature of the Porcupine, observed by Dodge (1967) and Jones (1973).

Wintering areas were on more moist soil and closer to a permanent water supply than control areas (Table 1). This may have been owing to a greater propensity for trees to windthrow in these wetter areas, but this was not indicated by the distance to another den measurement, which did not show fewer dens in the control areas. Tracks indicated that some Porcupines used open water. But availability of drinking water probably was not an important reason for the choice of the area since streams were frozen most of the winter. Shapiro (1949) noted that one Porcupine visited water regularly, but that others did not utilize open water when it was available.

There were significantly more conifers in the winter denning areas than in the control areas ($t = 2.1$, $df = 10$, $P < .05$) on the basal area. In addition to supplying important winter food,

TABLE 1—Comparison of characteristics of Porcupine wintering areas and control areas during the winter 1973–74 in central New Brunswick

	Wintering areas		Control areas		Mann-Whitney statistic
	Median	Range	Median	Range	U
Soil Moisture					
Scale 1–10	5.8	3–8	4.0	3–7	335*
Underbrush					
Scale 1–5	2.4	1–4	2.3	1–5	246
Crown closure					
Scale 1–3	1.1	1–2	1.3	1–3	276
Slope (%)	0.0	0–8	1.4	0–10	256
Distance to water (m)	24.5	8–65	28.3	10–70	204
R	0.92	0.74–1.13	0.86	0.52–1.10	271
Distance to water (m)	42.5	6–90	135.0	5–750	416**
No. species per plot	7.5	5–11	7.4	4–10	262
No. trees per plot	470	287–873	414	196–932	266

*$P < 0.01$

**$P < 0.001$.

[a]$n_1 = 22$, $n_2 = 20$.

[b]A measure of spatial distribution of the trees, R = 0 is maximum aggregation; R = 1 is random; R = 2.1491 is maximum spacing (Clark and Evans (1954)).

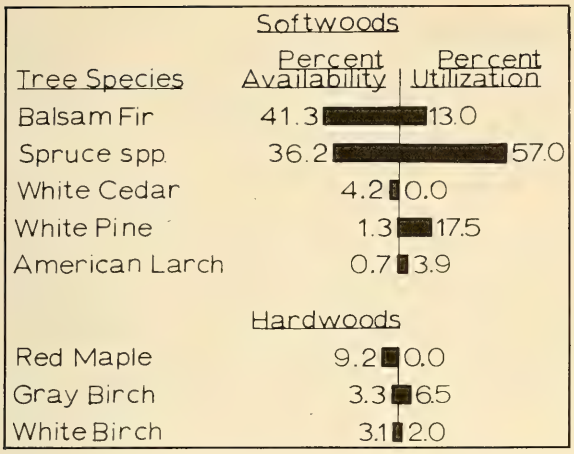

FIGURE 1. Comparison of availability of tree species and Porcupine utilization of these species through bark-feeding in central New Brunswick during the winter of 1974–75.

conifers offered more shelter than hardwoods. Tracks showed that Porcupines, when travelling, frequently used the firm snow under conifer branches.

A Porcupine may use a den extensively in one wintering area, but use a roost tree after shifting to a different area the same winter. This observation, together with the fact that any windthrown tree was used as a den site, indicates that the den site is not of primary importance in selection of the wintering area.

The availability of tree species in percentage on the wintering areas compared with utilization in percentage by bark-feeding is shown in Figure 1. Porcupines showed preference for spruce, White Pine (*Pinus strobus*), Eastern Larch (*Larix laricina*), and Gray Birch (*Betula populifolia*). They also fed on Balsam Fir (*Abies balsamea*) and White Birch (*Betula papyrifera*). Radvanyi (1953), who studied Porcupine in the same locality, found that they preferred Eastern Larch and Red Spruce over Balsam Fir. Other authors (Curtis 1944; Shapiro 1949; Dodge 1967) have also reported that feeding was more common on spruce than on Balsam Fir. Ninety one percent of the bark-feeding was on conifers, confirming the results of Gabrielson (1928), Reeks (1942), and Radvanyi (1955).

Red Maple and Eastern White Cedar (*Thuja occidentalis*) were not utilized, although present in fair numbers (Figure 1). Eastern Hemlock (*Tsuga canadensis*), Trembling Aspen (*Populus tremuloides*), Largetooth Aspen (*Populus grandidentata*), American Mountain-ash (*Sorbus americana*), Yellow Birch (*Betula alleghaniesis*), Pin Cherry (*Prunus pensylvanica*), and Striped Maple (*Acer pensylvanicum*) were present in small numbers but not utilized. Bark-feeding was recorded at 20 of 22 wintering areas (91%) and at 13 of these more than 70% of the bark-feeding was concentrated on one tree species. But it was not the same species at all areas (spruce spp., 8; Gray Birch, 2; White Pine, 2; Balsam Fir, 1). Little winter bark-feeding on Eastern Larch was found, although it was heavily utilized during spring and fall. Spring and fall feeding could not be accurately separated from winter feeding during our sampling, so the preference shown for Eastern Larch (Figure 1) may not be winter feeding.

Bark-feeding seemed to be influenced by the composition of the forest. Every tree species, except Red Maple, that made up over 0.5% of the trees in the plots, was utilized. Eastern Hemlock, which was present in small numbers, was not utilized; other studies (Curtis 1944; Curtis and Kozicky 1944; Shapiro 1949; Krefting et al. 1962; Dodge 1967; Kelly 1973) have shown it to be preferred food where it was common.

Twig-feeding was recorded at 13 of the 22 wintering areas (59%) and was the only feeding noted at one area. White Cedar was the most important food species for this type of feeding and a preference was shown for this species (Figure 2). There was little overlap among trees on which bark-feeding and twig-feeding occurred. Nine trees showed evidence of both types of feeding.

The 330 trees utilized for feeding represented

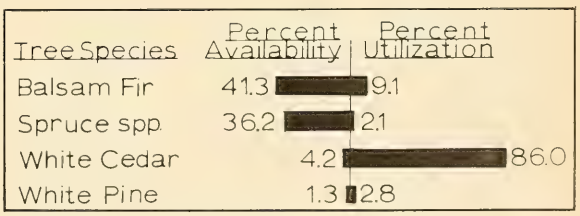

FIGURE 2. Comparison of availability of tree species and Porcupine's utilization of these species through twig-feeding in central New Brunswick during the winter of 1974–75.

3% of the trees available on the wintering areas. Winter feeding was concentrated in the wintering areas. Only 13 trees (0.13%) were utilized for feeding in the randomly selected control plots. The median distance travelled to a feeding tree was 16.6 m, although this is based on the 30-m radius plot. Some Porcupine travelled farther than 30 m to feed.

These results have implications for forest managers in areas similar to this study area. Porcupine winter foods vary depending on availability, so there may be feeding on any tree species that makes up a substantial part of a stand. Damage will be greater in areas of moist soil near a permanent water supply. Feeding on Eastern Larch, which is utilized principally during spring and fall, will not be restricted to wintering areas and removal of all suitable dens and roost trees from these stands will not protect them.

Acknowledgments

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Use of Forest Clear-cuts by White-tailed Deer in Southern New Brunswick and Central Nova Scotia

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Drolet, Charles-A. 1978. Use of forest clear-cuts by White-tailed Deer in southern New Brunswick and central Nova Scotia. Canadian Field-Naturalist 92(3): 275–282.

White-tailed Deer (*Odocoileus virginianus*) activity was monitored in all seasons in clear and selective forest cuts located in southern New Brunswick and central Nova Scotia by measuring browsing levels, pellet-group distribution, and track patterns. Surveys showed use to be related to distance from cover, with small cuts (up to 60 ha) showing more use near the center. The edge/center ratio was inverse and increased at increasing rates in larger cuts (up to 400 ha) even when browse availability remained fairly constant. Use dropped considerably in clear-cuts in winter with no use being recorded in snow depths exceeding 70 cm. Selective cuts were used continuously and deer chose areas offering denser crown closure and better footing as snow depth increased. Optimum size of clear-cuts and the necessity of leaving residual cover for winter use by deer are discussed.

Key Words: White-tailed Deer, clear-cutting, forest management, forest cutting, forest mammals, forest browsers.

Clear-cutting is the most widespread means of forest harvesting in the Maritimes. Mechanized harvesting, increasing acreages harvested annually, and larger-size clear-cuts where uniform stands permit are all increasing the impact on land and wildlife.

Wildlife needs have been generally ignored in the past cutting plans. In New Brunswick, the Forest Resource Study Report (Tweedale 1974) recommended that wildlife be given the same consideration that is accorded to fiber production with multiple use the prevailing practice. Yet, the necessity of modifying shape and size of clear-cuts for the benefit of wildlife has not been translated into legislation, partly owing to the lack of basic information pertaining to wildlife needs. In Nova Scotia, one company has voluntarily begun harvesting by strip cutting. The benefits to White-tailed Deer are usually short-lived because intervening strips are felled within five years after initial cut. In Maine, legislation is now controlling forest harvesting. Clear-cuts do not exceed 40 ha, and cutting plans for areas in the vicinity of deer yards have to be reviewed by biologists (S. D. Schemnitz, unpublished paper presented in 1973 at the International Union of Forest Research Organization meeting (IUFRO), Budapest, Hungary).

Information is needed on the interactions of clear-cuts and wildlife, particularly ungulates, in order to better adapt forest harvesting to wildlife requirements.

Study Area

Fifteen cuts were selected for study, seven in Cumberland, Pictou, Guysborough, and Hants Counties, Nova Scotia, and eight in New Brunswick within a 50-km radius of Fredericton (Figure 1). With this selection, a variety of conditions pertaining to cut sizes, type of pre-existing forest stand, and distance of cuts from winter deer yards were sampled (Table 1).

In New Brunswick, summer and fall activity of White-tailed Deer was monitored in the three Dunbar clear-cuts, and winter activity in six different cuts located near or in wintering areas. The three Dunbar cuts originating from mixed and hardwood stands had a rich woody-browse regeneration which created cover for small mammals and made most of the whole area attractive to browsers. The area had been cut 4–6 yr previous to the study and only a few scattered patches of spruce remained as cover. The cuts surveyed in winter were all located near dense cover used by deer as concentration areas. Portobello River cut, Acadia Forest and Rooth Station were similar areas of recent selective cuts in predominantly softwood cover composed of Balsam Fir (*Abies balsamea*), Hemlock (*Tsuga canadensis*), and Red Cedar (*Thuya occidentalis*). The hardwoods present were usually Red Maple (*Acer rubrum*), White Birch (*Betula papyrifera*), and occasional Red Oak (*Quercus borealis*). Cedar and hardwoods generally had been left by loggers as non-commercial species.

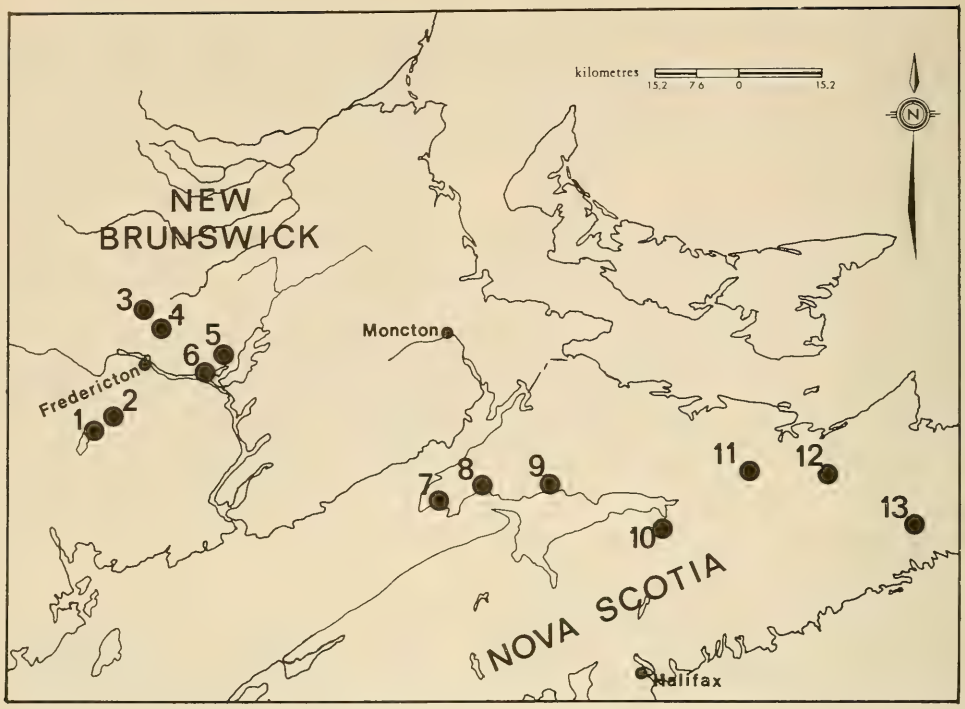

FIGURE 1. Map showing location of cuts surveyes. (1) Oromocto Lake, (2) Rooth Station, (3) Dunbar, (4) Manzer Brook, (5) Acadia Forest, (6) Portobello, (7) West Advocate, (8) Ninemile Brook, (9) Moose River, (10) Urbania, (11) Lorne, (12) Kerrowgare, (13) Country Harbour.

Oromocto Lake and Manzer Brook cuts were similar large-size clear-cuts surrounded by remaining spruce and mixed stands. Some strip-cuts could also be found near Manzer Brook.

Of the seven cuts surveyed in Nova Scotia, one (Moose River) was located near a wintering area while all but one (West Advocate) originated from softwood stands. All but one had been cut 2 to 6 yr prior to the survey (West Advocate was 10 yr old). Their dimension varied from 5 to 12 ha in Urbania (strip-cuts) to 400 ha in Lorne, with West Advocate (36 ha), Ninemile Brooke, Kerrowgare, and Country Harbour (60–70 ha) intermediate. The shape of cuts varied from nearly square (West Advocate, Ninemile Brook, Kerrowgare, Lorne) to elongate (Country Harbour, Moose River). The only true strip-cuts (100 by 400 m) were at Urbania (Table 1).

The study area in New Brunswick has a modified continental climate, despite its maritime location. Winters are mild with a heavy snowfall. The mean annual precipitation is 1050 mm with a mean annual snowfall of 2800 mm, and a mean low of -10.0°C in January (Canada Department of Transport, Metereological Branch).

The areas selected for study in Nova Scotia were located in various ecoregions. Urbania was included in the Maritime lowland ecoregion described by Loucks (1962); West Advocate, Ninemile Brook, and Moose River in the Spruce-Fir coast zone, where the outstanding features of the climate are late spring, cold summer, and frequent fogs (Putnam 1952); Lorne and Kerrowgare in the Sugar Maple–Hemlock–Pine zone, where local climate is characterized by low summer precipitation, warm summer temperature, and high evapotranspiration.

Methods

Direct observations and track counts on snow, mud, or sand transects, and pellet-group counts were used to monitor activity in all seasons while browse surveys were used to assess use in late fall, winter, and spring.

Track counts were made by walking transects (on snow, mud, or sand) distributed throughout

TABLE 1—Characteristics of forest cuttings surveyed in New Brunswick and Nova Scotia

Location	Size (ha)	Shape and dimensions (m)	Years since cut	Original stand composition	Type of cut	Proximity to deer yarding area
Urbania (4 strips)	6–12	strip	6	softwood	clear cut	not related
West Advocate	36	square 160 × 560 400 × 560	9	mixedwood	clear cut	not related
Ninemile Brook	60	rectangular 640 × 965	3	softwood	clear cut	not related
Kerrowgare	68	rectangular 480 × 400	3	softwood	clear cut	not related
Country Harbour	70	rectangular 400 × 1600	6	softwood	clear cut	not related
Dunbar 1	92	square 1070 × 790	6	mixedwood	clear cut	not related
Moose River	113	square 965 × 1290	3	softwood	clear cut	deer yard
Dunbar 2	187	square 1280 × 1490	6	mixedwood	clear cut	not related
Lorne	404	square 1900 × 2000	4	softwood	clear cut	not related
Dunbar 3	407	rectangular 1470 × 2651	6	mixedwood	clear cut	not related
Rooth Station	37	square 400 × 730	5	softwood, mixedwood	selective (hardwood and cedar left)	deer yard
Manzer Brook 1	8	strip 40 × 2000	4	softwood	clear cut	deer yard
Manzer Brook 2	11	square 400 × 300	4	mixedwood	clear cut	deer yard
Acadia Forest	77	square 850 × 900	4	softwood	selective (hardwood and cedar left)	deer yard
Portobello	24.5	rectangular 760 × 320	5	softwood, mixedwood	selective (hardwood and cedar left)	deer yard

cuts surveyed along existing roads and taking note of tracks crossing the transects. Transects were as long as conditions permitted. They were continuous in snow and mud (up to 10 km long) and limited to 45–60 x 2 m in sand or loose soil in summer. Sand transects were raked after each reading, but a fresh snowfall was necessary to permit further readings in snow. Summer 1974 track monitoring continued through periods of up to 1 mo and winter monitoring was done for the duration of 1973–74 and 1974–75 winters (November 1973 to April 1974, and 10 September 1974 to February 1975). Track counts gave an indication of the period when use occurred. Results were used to help evaluate browse survey data.

Browse surveys were based on Batcheler's (1973) joint point-distance nearest-neighbor distances method. Density of stems browsed (where at least one twig had been browsed) was estimated from a set of distances from a sample point to the nearest browsed stem, from that stem to its neighbor, and from that neighbor to its nearest neighbor. Search distances were usually between 3 and 4.5 m, but in order to obtain measurements from at least 50% of points, search distances of up to 7.5 m were used where densities were low. Points were distributed at 30-m intervals along straight lines 300 m long. Lines were positioned approximately paralleling the edge of the cut (Figure 2). In cuts used during spring and fall the lines were located at three positions in relation to the edge: within 75 m, at approximately 300 m, and in the center or 680 m

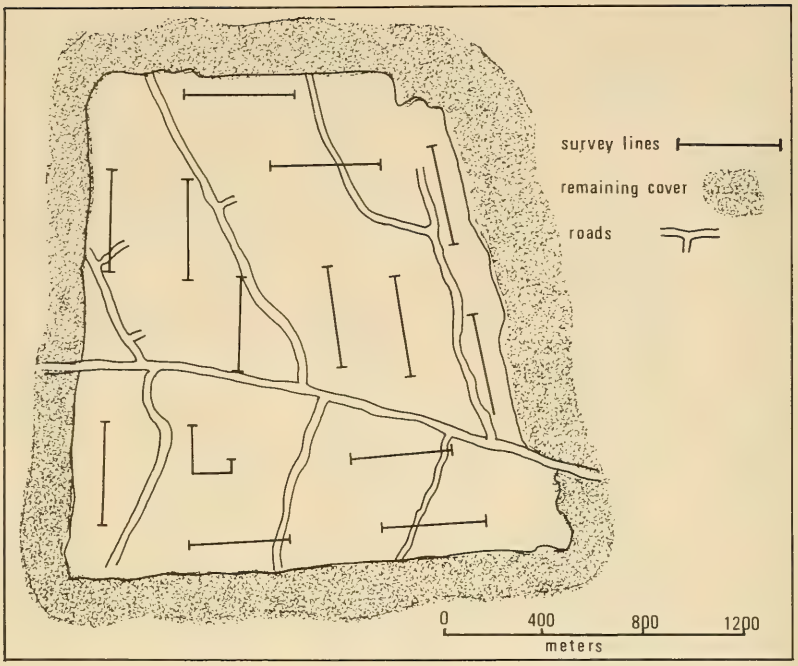

FIGURE 2. Map of Dunbar 2 clear-cut showing typical layout of survey lines. Each line is made of 10 sampling points uniformly spaced. Remaining cover extends in all directions from cut area much beyond boundary shown.

from the edge, whichever was least. In wintering areas, since deer travel was reduced, distances from edge to browse survey lines were smaller and lines were located at 10 m and 30 m from the edge. The first point on a line was positioned at a random distance from a chosen starting location. There was no effort made to use the same lines in subsequent browse surveys. On one occasion lines were designed to evaluate the effects of a road on level of browsing. Sample points were located at increasing distances from cover (100 to 500 m) and at various distances from roads (10, 20, and 30 m). Roads surveyed ran perpendicular to cover.

Pellet group counts were conducted on study areas in Nova Scotia again using Batcheler's (1973) method.

Deer activity in selective cuts bordering wintering areas in New Brunswick (Portobello and Rooth Station) was further related to residual cover by measuring percentage of crown closure and total basal area of cover used in various snow depth conditions. Measurements were taken at 15-m intervals following fresh deer tracks. Total snow depth and actual sinking depth of deer were measured with a wooden ruler. Four measurements of crown closure were taken at each site at 90° intervals using a spherical densiometer (Lemmon 1956) while total basal area and softwood basal area were measured by the prism method (Bell and Alexander 1957). All fresh deer tracks were followed in each area each time the survey was run (2–3 d after new snow).

Results

Use of clear-cuts in fall and spring by deer as shown by browse surveys made in late spring (April–May) and late fall (October) showed a definite relation to distance from cover. Small cuts (up to 60 ha) were browsed more heavily near the center than at the edge (Table 2, Figure 3). In larger cuts, browsing decreased at an increasing rate towards the center. A difference of 57% was measured in 92-ha cuts, 76% and 99% in 113-ha and 187-ha cuts, and 92% in 400-ha cuts. I found that simple correlation coefficients between browsing intensity and distance from cover increased and became statistically significant as the cut size increased. In spring 1974, correlation coefficients were –0.22 in a 92-ha cut (N=7), –0.49 in a 187-ha cut (N=14), and

TABLE 2—Mean (± 95% confidence limits) densities of woody stems browsed (twigs produced in growing season immediately preceding) on forest cutovers in New Brunswick and Nova Scotia surveyed in spring and fall 1974 and 1975

			Edge (75 m from edge)			Intermediate (300 m from edge)				Center (up to 680 m from edge)			
Area	Season of survey	Size (ha)	N	Availability, stems/ha	Use, stems/ha	N	Availability, stems/ha	Use, stems/ha	Difference from edge use in %	N	Availability, stems/ha	Use, stems/ha	Difference from edge use in %
Urbania	Spring 1974	6–12	5	7335 ± 1305	1947 ± 473	—	—	—	—	3	7963 ± 2525	2259 ± 792	+ 16
West Advocate	Spring 1974	36	2	17102 ± 4450	1748 ± 1011	—	—	—	—	1	9095	5134	+ 193
Ninemile	Spring 1974	60	2	—	1450 ± 1313	—	—	—	—	2	—	3381 ± 3400	+ 133
Kerrow-gare	Spring 1974	68	3	1268 ± 478	1011 ± 210	2	5159 ± 2769	1279	+ 26	1	5361	581	- 43
Country Harbour	Spring 1974	70	2	—	4601 ± 3117		—	—	—	2	—	1647 ± 374	- 64
Dunbar 1	Spring 1974	92	4	—	816 ± 339		—	—	—		—	358 ± 241	- 57
	Fall 1974	92	4	29291 ± 4100	2451 ± 1224		—	—	—		21485 ± 1142	350 ± 159	- 86
	Spring 1975	92	4	22641 ± 4500	1097 ± 528						20702 ± 6800	425 ± 233	- 62
Moose River	Spring 1974	113	5	—	3051 ± 1600					3	—	740 ± 50	- 76
Dunbar 2	Spring 1974	187	7		933 ± 327	5		445 ± 251	- 53	2		18 ± 28	- 99
	Spring 1975	187	7	42853 ± 8573	791 ± 214	5	29822 ± 3784	168 ± 55	- 79	2	31351 ± 6557	40 ± 48	- 95
Lorne	Spring 1974	404	7	2451 ± 893	1495 ± 495	5	1868 ± 849	791 ± 254	- 47	3	1377 ± 608	267 ± 126	- 82
Dunbar 3	Spring 1974	407	8		747 ± 283	7		233 ± 111	- 69	2		25 ± 14	- 97

–0.54 in a 407-ha cut (N=14). Only the last figure, 0.54, is statistically significant at 0.05 level. In spring, 1975, correlation coefficients were –0.24 in a 92-ha cut, (N=7) and –0.64 in a 187-ha cut (N=14), the latter figure being statistically significant at 0.05 level. I should emphasize here that browsing intensity per se is not a suitable variable to use to compare utilization of various cuts by browsers, as many factors vary from one cut to another. What is comparable is the rate of change in intensity of browsing from levels observed at various distances from the edge in a given cut. The density of fecal pellet groups followed the same pattern, with densities higher in the center of cuts up to 68 ha, and lower in the center of larger cuts (Table 3). This trend was not reflected in the availability of browse. Its level was quite similar throughout cuts where it was measured (Table 2); however, the availability may vary greatly between cuts.

Deer used roads for travelling through cuts as indicated by the higher intensity of browsing

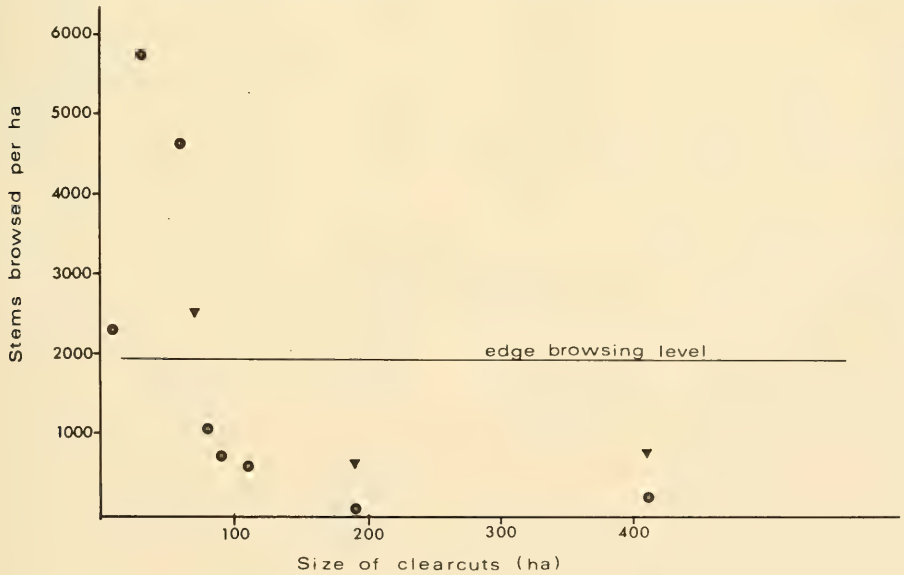

FIGURE 3. Levels of browsing intensity in center (solid circles) and halfway to center (triangles) of clear-cuts in relation to size, with edge browsing levels kept constant.

TABLE 3—Estimated densities (means ± 95% confidence limits) of fecal pellet groups of White-tailed Deer on transects in forest cutovers in Nova Scotia, fall 1974

		Edge (75 m from edge)		Intermediate (300 m from edge)			Center (up to 680 m from edge)		
Area	Size, ha	N	Pellet groups/ha	N	Pellet groups/ha	Difference from edge (%)	N	Pellet groups/ha	Difference from edge (%)
Urbania	6–12	2	295 ± 4				2	668 ± 594	+ 126
Ninemile	60	2	259 ± 136					78 ± 25	− 70
Kerrowgare	68	2	152 ± 65				1	187	+ 23
Country Harbour	70	2	3838 ± 294				1	777	− 80
Moose River	113	4	987 ± 763				2	121 ± 91	− 88
Lorne	404	4	359 ± 120	3	59 ± 23	− 83			

near roads. Intensity dropped rapidly away from roads: at 30 m distance, it was only 35% of roadside level. This drop in intensity was more spectacular 200 m from cover (85%) than closer to cover (10 m, 57%) (Table 4).

Mean track counts (±SD) on sand transects in late summer (10–21 September) 1974 showed a higher level of use on a 187-ha clear-cut than on a 407-ha cut (2.20 ± 1.29 vs. 0.58 ± 0.23 tracks per transect overall average).

Deer use of clear-cuts dropped considerably in winter. Use of the three Dunbar clear-cuts in 1973–74, as shown by track counts, stayed constant through November in 5–6 cm of snow, decreased in December, and decreased further in January. Use remained low in February and March, and increased in mid-April to the original level. When snow was 10–20 cm deep in 1974–75, deer used open areas in selective cuts and were seen travelling freely in clear-cuts. In 25–30 cm of snow, deer were observed in clear-cuts 70 m from cover, and crossing clear-cut strips 90 m wide to patches of dense cover. In snow depth of 50 cm, most of the activity was under cover and very little feeding occurred in the open. In 50–60 cm of snow, heavy browsing was found on the edge of clear-cuts and deer were restricted to denser areas in selective cuts. Less crossing from cover to cover occurred in 60–70 cm of snow. When snow depth exceeded 70 cm deer did not use clear-cuts at all, except on the edge (as far as the last conifer).

Deer used selective cuts continuously in all snow conditions. They adapted to increasing snow depth by making trails in sites protected by denser crown closure and a larger softwood basal area. Figure 4 represents that relationship. In three selective cuts, where 14, 27, and 41% mean average crown closure could be measured, up to 60% crown closure was measured along deer tracks in the deepest snow conditions. Each point of Figure 4 represents the average of measurements taken in a given set of snow conditions. This curve shows that as sinking depth increases through changing snow conditions, deer restrict their movements to areas of selective cuts that offer denser crown closure and a better footing. Often, the same sites are used, but deer travel closer to base of trees, and in more direct line between trees.

TABLE 4—Mean densities of woody stems and percentages browsed on forest cutovers in relation to road proximity, May 1975

Distance from mature forest (m)	Browsed stems, ha				
	Along road	Percentage browsed	30 m from road	Percentage browsed	Difference in %
10	3446 (44 011)	7.8	1507 (29 917)	5.03	− 57
200	171.6 (32 608)	0.52	25.5 (70 956)	0.03	− 85
500	≃ 0	0	≃ 0	0	
All data	939.3 (34 264)	2.74	315.9 (34 685)	0.9	− 33

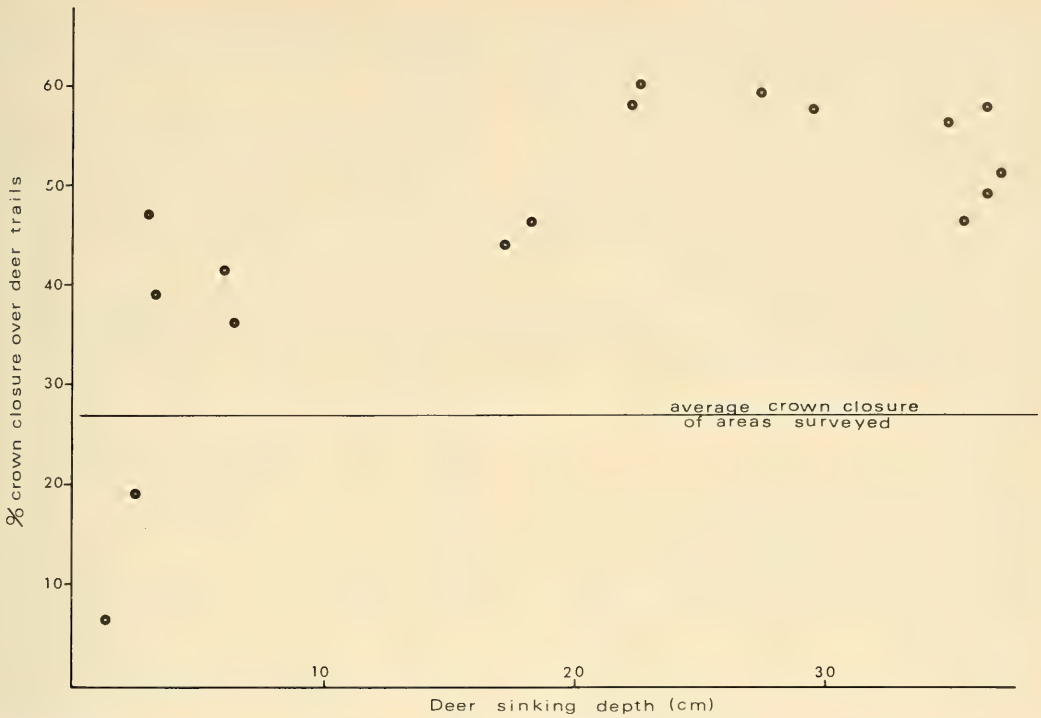

FIGURE 4. Relationship between sinking depth in snow and crown closure in cover sought by deer in selective cuts in winter 1974–75. Data from three cuts and 17 surveys are pooled in this graph.

Discussion and Conclusions

Clear-cuts are obviously attractive to deer, but their characteristics may limit their usefulness. Clear-cuts originating from mixed stands and not exceeding 60 ha are fully used by deer in fall, spring, and probably summer, at least during early successional stages (4–6 yr cut). In larger cuts, deer use is more restricted to edges. Browsing intensity in relation to distance from edge tends to be related to the size of cut. In larger cuttings there is a marked decline of use away from edge while in smaller cuttings this relationship is less pronounced or non-existent. Such a trend was also found by G.D. Hamilton and P.D. Drysdale with Moose (*Alces alces*) in Ontario (paper presented at the 10th Moose Workshop, Winnipeg in 1975). This would indicate that deer are more attracted to smaller openings and use them more thoroughly than the larger ones; the distance from cover becomes more important in larger cuttings. This conclusion applies to square or nearly square-shape cuts. This preference for smaller cuts was also found by McCaffery and Creed (1969 as reviewed by E. S. Telfer in a paper presented at the Canadian Society of Wildlife and Fishery Biologist annual meeting, Saskatoon, February 1972).

In Alberta and New York, use of clear-cuts by deer was considerably reduced in winter, as found by Stelfox et al. (1973) and Krull (1964). In this study, use of clear-cuts located in predominantly summer range areas was reduced in winter even in the absence of snow. Snow-track surveys indicated that deer did not use clear-cuts, however small, as soon as soft snow accumulated to a depth of 30–45 cm. At those levels of snow accumulation, deer were restricted to dense cover and selective cuts. Crown-closure measurements in deer trails in selective cuts were positively correlated with behavioral changes regarding food seeking activity and mobility in all snow conditions. Deer were able to use feeding areas in the selective cuts with relative ease through an altered pattern of trail site selection which made optimum use of whatever softwood trees were left. These observations demonstrate the necessity of leaving some cover

if access by deer to a logged area is desired. In deep snow conditions deer stopped using areas that were entirely void of softwood cover. As soon as travel conditions improved, as through crust formation, deer used open areas freely.

Benefits from actual use have, however, to be balanced with the necessity of managing for the future, and large clear-cuts where deer access is naturally limited need to be created if cover regeneration is wanted (Verme 1965).

More research is needed to clarify some aspects of the effects of forest-cutting practices on wildlife, particularly concerning their long-term effects.

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Seasonal Concentrations of Grizzly Bears, North Fork of the Flathead River, Montana

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Grizzly Bears were observed to concentrate during spring and fall in the flood plain, North Fork of the Flathead River, during 1972–1975. Bears were particularly numerous during the late spring of 1974 when a heavy snow pack remained at the higher elevations. Important habitats were wet meadows where rhizomatous grasses and several key forbs were eaten, and recently flooded alluvial stands where roots and tubers were consumed.

Key Words: Grizzly Bear, habitat, river flood plains, diet.

The Grizzly Bear (*Ursus arctos*) and its habitat have come under increasing attention recently as hunting access and human developments intrude farther into the bear's range. In 1975, the Grizzly Bear was listed as a threatened species by the U.S. Fish and Wildlife Service for the lower 48 states in accordance with Section IV of the Endangered Species Act of 1973. This note reports on concentrations and feeding habitats of Grizzly Bears in the North Fork of the Flathead River, Glacier National Park, Montana, and adjoining British Columbia (Figure 1) during 1973, 1974, and 1975.

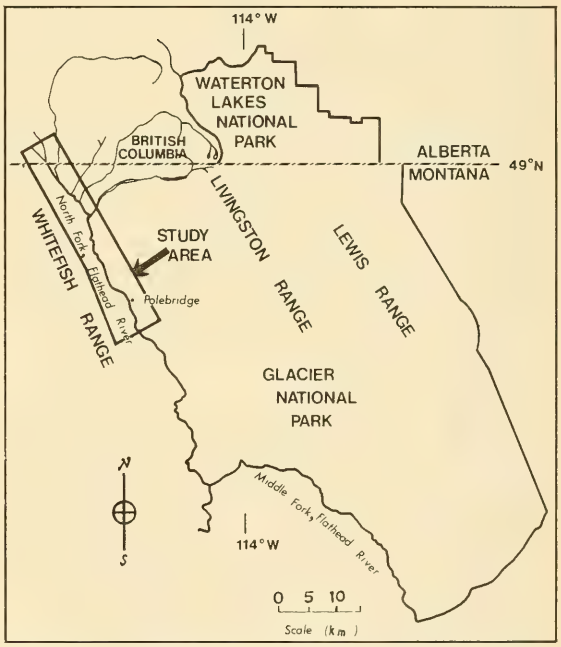

FIGURE 1. Map showing study area located in valley of the North Fork of the Flathead River, along the western boundary of Glacier National Park.

Study Area

Topography of the study area includes glaciated peaks and ridges of the Livingston and Whitefish Ranges, morainal uplands, and flood plains bisected by the river. The river flood plain is braided, with differentially sorted and glacial-alluvial deposits forming benches of variable heights. The dominant vegetation is coniferous forest dominated by Lodgepole Pine (*Pinus contorta*), Subalpine Fir (*Abies lasiocarpa*), Douglas Fir (*Pseudotsuga menzeisii*), and spruce (*Picea engelmanii* and *P. glauca* or hybrids).

Eight major vegetation types were recognized, primarily by dominant canopy. Characteristically, a wash/cottonwood type (dominated by *Populus trichocarpa, Salix amygdaloides, S. exigua* ssp. *interior*) occupies low sites adjacent to the river, as does the spruce type. Increasingly higher alluvial benches are characterized in turn by sagebrush (*Artemesia tridentata* and *Festuca idahoensis*), bunchgrass (*F. scrabella, Agropyron spicatum,* and *Danthonia intermedia*), and Lodgepole Pine savanna types (*Pinus contorta, F. scrabella,* and *A. smithii*), as described by Singer (1975) and Koterba and Habeck (1971). Aspen (*Populus tremuloides*) willow/sedge, spruce, and wet meadow types occupy silt beds or the deltas of tributary streams. The spruce type was identified as the *Picea engelmanni–glauca/Clintonia uniflora* forest type of Pfister et al. (1975) and the rest as the *Abies lasiocarpa/Clintonia uniflora* forest habitat type.

Methods

Grizzly Bears were observed incidental to ungulate studies during 5156 km of backcountry travel, vehicle travel, and nine aerial surveys over the 3-yr period. Travel was conducted over systematic routes selected to sample the vegetation types roughly in proportion to their occurrence. Most observations were made from horseback and vehicles; the four observations during aerial flights were made by circling low over small meadows.

Observations of Grizzly Bears were recorded and sketches were made of their color and physical characteristics. Feeding sites were identified as those of Grizzly Bear through tracks or hair. Feeding habits were recorded by observation through binoculars or from feeding sign at recently vacated sites. One bite, or what was assumed to be one bite (Knowlton 1960), was recorded in sites where bear tracks and trails were visible because of dew and high moisture levels. Only sites with 100 or more bites were tabulated. In situations where Grizzly Bears, Elk (*Cervus canadensis*), and White-tailed Deer (*Odocoileus virginianus*) fed in the same vegetation types, a coefficient of dietary overlap was calculated (Zaret and Rand 1971).

Results

Grizzly Bear feeding sites, both grazing and digging, were numerous during the spring and fall, and 354 were recorded during the 3-yr period. River flood plains and tributary drainage comprised only 16 and 14% of the area, respectively (Singer 1975), but 149 (42%) of the feeding sites were in flood plains and 135 (38%) were along tributary drainages (in wet meadow, aspen, and willow/sedge sites). Most of the area is coniferous forest (i.e., 70%), yet only 20% of the grizzly feeding sites were observed there. Actual observations were undoubtedly biased towards the open types where bears are more visible. For example, 21 (81%) of the actual observations of bears were made in one type, wet meadow.

Strong preference was indicated for certain key sites within open habitats. For example, three different adult grizzlies were observed grazing in the same 100-m^2 site in one wet meadow during a 7-d period. Two adult grizzlies and two Black Bears (*U. americanus*) fed on the same site (1 ha) in a wet meadow during a 15-d period. Large areas within the flood plains were extensively dug or overturned.

TABLE 1—Grazing food habits of Grizzly Bears at 26 feeding sites in mesic habitats (wet meadows, aspen, willow) within morainal drainages, North Fork of the Flathead River, Montana

Plant species	Frequency (%)
Elymus glaucus	8
Agropyron smithii	8
Dactylis glomerata	8
Poa. spp.	5
Phleum pratense	3
Other grass species	2
Total grasses	34
Heracleum lanatum	31
Senecio spp.	26
Taraxacum officinale	3
Circium canadensis	1
Other forb species	2
Total forbs	63
Total roots	3

During spring, Grizzly Bears grazed primarily upon dense stands of rhizomatous grasses in wet meadows, particularly upon Timothy (*Phleum pratense*), Western Wheatgrass (*Agropyron smithii*), *Poa.* spp., *Elymus glaucus,* and Orchard Grass (*Dactylis glomerata*) (Table 1).

Forbs eaten by Grizzly Bears during spring included Cow Parsnip (*Herculeum lanatum*), hawkweeds (primarily *Senecio pauperculus* and *S. triangularis*), and *Angelica* spp. (mainly *Angelica dawsonii*). These forbs were eaten during succulent stages, particularly hawkweed, the basal leaves of which were eaten during initial green-up. Hawkweed was found in the flooded sites of wet meadows, and Cow Parsnip and *Angelica* spp. were found under partial canopy stands of willows and aspen or on the edges of spruce stands. All forbs were found on mesic sites where silt and nutrient deposition occurred.

Most digging by grizzlies in the river flood plain occurred on recently disturbed sites located on islands, dry channels, and usually within 300 m of the existing river course. These early successional sites were dominated by such pioneers as *Dryas drummondi,* Black Cottonwood seedlings, Peach-leaf Willow (*S.*

amygdaloides), and River-bank Willow (*S. exigua interior*). Grizzlies fed extensively in spring and fall upon tubers and roots of Wild Onion (*Allium cernum*), *Astragalus* spp. (*A. robinsii* and *A. spatulatus*), Kinnikinnik (*Arctostaphylos uva-ursi*), *Oxytropis campestris,* and in the spring upon the entire plant of Glacier Lily (*Erythronium grandiflorum*).

Utilization of carrion by grizzlies was insignificant. Carrion was found in only five scats. Field observations included only one ungulate kill and three cases of scavenging by grizzlies. Several species of scavengers fed at a carcass at the same time, and few ungulate carcasses remained for longer than 24–28 h before being completely utilized. Mountain Lions (*Felis concolor*), Coyotes (*Canis latrans*), Bald Eagles (*Haliaeetus leucocephalus*), Golden Eagles (*Aquila chrysaetos*), Ravens (*Corvus corax*) and other corvids are common during winter and early spring. Carrion may be more important during spring to grizzlies in other areas such as Yellowstone National Park (Mealy 1975) or other portions of Glacier National Park (Martinka, C. J., unpublished report, National Park Service, 1972; Singer F. J., unpublished report, National Park Service, 1975).

Discussion

High densities of Grizzly Bears occurred during the spring and fall of all three years. During the most intensive period of study on the area, 26 observations of bears were made in a 40-d period in the spring of 1974. Observations were made from vehicle (13), on horseback (7), on foot (3), and during aerial survey (3). An attempt was made to estimate the spring density of bears during 1974. Positive and distinctive differences in size, physical characters, and coloration suggested that 21 different bears were observed, including 16 (76.2%) solitary adults, 2 (9.5%) subadults, and only 1 female with 2 (9.5%) cubs. Without artificial markers, errors could have been made with the 16 solitary adults because of mistakes in color description, human error, and poor light conditions, or actual color changes in the bears themselves. These possible errors were minimized by the excellent observation conditions in grassland habitats: many bears were approached to within 30 m on horseback and many others were observed for 1 to 2 h from vehicle or on foot. An absolute minimum of 12 adults was present based upon temporal records; for example, on three occasions two adults were in view at the same time and on five occasions two different adults were observed during a single day's travel.

Considering the solitary adults (12 or 16 different ones), cub (11–13%) and yearling (0%) ratios on the area are considerably less than mean cub and yearling ratios of 17% and 15%, respectively, for central Glacier National Park (Martinka 1974). The seasonal concentrations observed in the valley ecosystem were primarily males and/or non-productive females. The larger home ranges and/or behavioral dominance of male grizzlies (Pearson 1975) could explain how males utilize this area more than females. The spring in which the greatest number of observations was made, 1974, was a late spring with heavy snow pack remaining in the mountains in May, a situation which may have caused greater concentrations of grizzlies in the valley (C. J. Martinka, personal communication).

In spring, the continuous dense stands of rhizomatous grasses facilitated extensive grazing by Grizzly Bears. Distribution of the grasses is related to deep silt deposits, high moisture levels, and past histories of grazing and haying during the period 1900–1940. Continued dominance of these sites by rhizomatous grasses is apparently due to the high moisture levels, extensive Elk grazing and rutting activity, grazing and rooting by grizzlies, and the burrowing activity of Columbian Gray Squirrels (*Spermophilus columbianus*).

Hawkweeds produced new growth earlier than other forage owing to early snow removal by flooding and was preferred by Elk, Whitetailed Deer, and Grizzly Bears. The limited occurrence of hawkweeds resulted in interspecific contacts; five observations were made of ungulates waiting for grizzlies to leave feeding sites. The contacts were not felt to represent competition, since Elk and whitetails eventually obtain access to the forage and since the period of combined use was short, about 15 d in 1974. In addition, spring dietary overlap coefficients between Elk and Grizzly Bears was only 0.47, and between whitetails and Grizzly Bears was only 0.15. Zaret and Rand (1971) felt that a

coefficient of 0.60 or greater implied ecological importance.

Pearson (1975) reported extensive use of braided flood plains by grizzlies in the Yukon Territory, and suspected that flood plains were higher in energy resources because of the deposition of nutrients. Grizzly habitat in the North Fork of the Flathead River seems analogous; 80% of digging and grazing sites were observed in the river flood plains or in habitats associated with tributary streams. Although these sites may have been easier to locate in open areas, it may be concluded that my proportional travel in heavy coniferous cover and the recording of feeding sites based on tracks probably reduced observational biases to the point that they did not obscure habitat use.

The importance of the flood plain of the North Fork Flathead River to Grizzly Bears should be recognized and steps taken to preserve the area as a grizzly feeding area. Possible disturbances due to proposed coal mining in the British Columbia portion of the drainage, oil and gas mining in Montana (Albert 1975), and the strong trend towards subdivision on the private lands are not compatible with preserving the flood plains as grizzly habitat.

This study was supported by the National Park Service. I thank Clifford J. Martinka, Glacier National Park, for advice and direction.

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Notes

First Record of the Atlantic Leatherback Turtle *(Dermochelys coriacea)* from Labrador

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Threlfall, W. 1978. First record of the Atlantic Leatherback Turtle *(Dermochelys coriacea)* from Labrador. Canadian Field-Naturalist 92(3): 287.

The northern limit of the range of the Atlantic Leatherback Turtle *(Dermochelys coriacea)* in the northwestern North Atlantic is normally given as "Newfoundland" (Bleakney 1965; Ernst and Barbour 1973; Conant 1975). This province covers a vast area, with its eastern seacoast running from approximately 46°40′N to 60°20′N. All records of sea turtles in this region refer to sightings or specimens taken in the Avalon Peninsula area, and particularly Conception Bay and Trinity Bay. Steele (1972) gave an account of a specimen taken in Conception Bay. During the past several years there have been a number of reports of sightings of this turtle species in the Avalon Peninsula area, in August and September. One was caught (150 cm, 227 kg) in September 1976, in salmon nets, at Western Bay, Conception Bay, and released unharmed (St. John's Evening Telegram, 23 September 1976).

In 1973 two specimens were obtained by the author. One was caught (harpooned and shot) near Princeton, Southern Bay, Bonavista Bay (48°25′N, 53°36′W) on 13 September 1973, some 19 km NW of the collection area of the specimen reported by Squires (1954), namely Dunfield, Trinity Bay. The specimen was a mature male, weighing approximately 500 kg and having a carapace length of 165 cm. The turtle was accompanied by five to six mackerel-sized fish, each of which had a blue back and white belly. The fish stayed with the turtle until it was actually taken out of the water.

The second specimen (mature female, containing ova; weight 379 kg; carapace length 147 cm) was shot 48 km NE of Nain, Labrador (56°45′, 61°00′W) in early September 1973. This location is approximately 1050 km NNW of any previous record, and extends the northerly summer range of this turtle into the frigid Labrador coastal region. Frair et al. (1972) noted the ability of leatherbacks to raise their body temperature 18°C above the temperature of the waters in which they were taken, by possible retention of heat from muscular activity. This must have been the situation obtaining in the case of the latter animal, which was taken from waters where the temperature could not have exceeded 6°C.

Small numbers of digenetic trematodes were found in the intestine of the male (two species) and a lone fluke was recovered from the gall bladder of the female. This is of interest in that only one species of endoparasite, *Astrorchis renicapite* (Leidy, 1856), has been recovered from this host to date (Yamaguti 1971). The helminths that were found will be described elsewhere.

I thank P. Curl, A. King, and C. Mugford for the turtle from Bonavista Bay, and E. Obed for the specimen from Nain. The help of Ian Strachan, M.H.A., is also gratefully acknowledged.

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Seasonal Occurrence of Silver-haired Bats (*Lasionycteris noctivagans*) in Alberta and British Columbia

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Specimen records of Silver-haired Bats (*Lasionycteris noctivagans*) from Alberta and British Columbia were reviewed. Results of our survey indicated that adult females migrate across southern Alberta in spring and return with juveniles in late summer and fall. Few adult males were recorded in Alberta. Evidence of migration or sexual segregation was not evident in this species in southwestern British Columbia.

Key Words: *Lasionycteris noctivagans*, seasonal occurrence, Alberta, British Columbia, migration.

Silver-haired Bats (*Lasionycteris noctivagans*) occur widely in British Columbia and Alberta (Cowan and Guiguet 1965; Soper 1964), but little is known of their seasonal occurrence and reproduction in these provinces. This bat is generally accepted as being migratory and the sexes are thought to have separate summer ranges (Barbour and Davis 1969). The availability of Silver-haired Bats submitted to the Animal Diseases Research Institute (Western) ADRI(W) for rabies-testing, and of museum specimens, presented the opportunity to examine aspects of the biology of this species in western Canada.

Methods

The sources of the 309 specimens differed between provinces; 6 of the 250 bats submitted to ADRI(W) were from British Columbia, whereas 9 of the 59 museum specimens examined were from Alberta. Approximately three-quarters of the museum specimens were secured through systematic collecting activities of museum personnel. Most of the remaining museum specimens and almost all of the bats submitted for rabies-testing were accidental discoveries of solitary roosting bats. Rabies-suspect bats from Alberta were collected from 1973 to 1976; those from British Columbia were collected in 1976. The museum collections date from 1900.

Age, based on the degree of closure of the finger epiphysis, and sex, when possible, were determined. Collection data were taken from specimen labels and from the records of ADRI(W). The uteri of 32 female rabies-suspect bats captured during the spring in Alberta were examined for pregnancy.

Results and Discussion

Most of the Silver-haired Bats collected in Alberta were from the southern and, to a lesser extent, the central areas of the province (Figures 1, 2). These are all assumed to have been migrating, since southern Alberta is largely treeless and likely not suitable habitat for the species (Barbour and Davis 1969). Central Alberta is largely aspen parkland and may offer suitable habitat; however, females with near-term fetuses, lactating females, or juveniles not sufficently developed to be independent of their mothers have not been found in this area.

Dorward et al. (1977) observed a bimodal pattern of submission of Silver-haired Bats for rabies-testing (Figure 3), presumably reflecting spring and fall migrations. Bats captured during the periods of peak submission were frequently collected in sheds and other man-made structures, situations also reported by Barbour and Davis (1969). Spring records occurred as early as 18 April (1974) and as late as 13 July (1975) in southern and central Alberta. No Silver-haired Bats were collected in this area between 13 July and 7 August.

Submissions of spring migrants to ADRI(W) declined from 33 in 1974 to 11 in 1976 but fall submissions were relatively constant from 1974 to 1976 in their timing, numbers, and geographical distribution. The observed variations in fall submissions were readily related to known changes in local concern about rabies. The change in numbers of spring submissions cannot be related to known factors. Over 25% of spring migrants have been captured in Calgary, a pattern not evident in fall submission, indicating that spring migrants may tend to concentrate their movements in the region of that city.

Location and timing of parturition in Alberta are essentially unknown. All 32 spring migrant females examined contained viable or resorbing embryos. Regardless of collection date, all embryos were considerably less than full-term, demonstrating

FIGURE 1. Spring and summer (18 April to 30 July) localities of Silver-haired Bats from British Columbia and Alberta, 1910 to 1976. Numerals in large symbols denote the number of specimens from a town or city.

FIGURE 2. Fall (1 August to 7 October) and winter (17 November to 5 March) localities of Silver-haired Bats from British Columbia and Alberta, 1915 to 1976. Numerals in large symbols denote the number of specimens from a town or city.

variation in timing of parturition. Only one specimen is positively from the maternity range of the species, that being a lacating female found 22 July 1974 in Peace River. That the specimen was rabid may account for even this single discovery. The paucity of such records suggests that the species avoids man-made structures during this time.

Presumed fall migrants in Alberta have been collected as early as 7 August (1976) and as late as 7 October (1975). In contrast to the observation of Barbour and Davis (1969) in parts of the southern and eastern United States, fall migrations in Alberta may be better defined than spring migration (Figure 3). During fall migration in Alberta, 134 juveniles were taken, nearly twice the number of juveniles that the 36 adult females captured during the same period could produce at the optimum rate of two young per female (Barbour and Davis 1969). Adults may follow an alternative route, travel more quickly, or tend to choose roost sites where they are less likely to be discovered.

Only four adult males were collected in Alberta, two in each of the spring and fall periods. This is in agreement with observations of extremely skewed sex ratios in other areas (Barbour and Davis 1969; Easterla and Watkins 1970; Kunz 1971). Juvenile sex ratio was near 1:1 (60 males to 55 females). These data suggest that female Silver-haired Bats migrate through southern and central Alberta in spring, and they and their young return during late summer and fall; adult males seldom follow this migration. The wintering area remains undocumented.

There is, however, little evidence of migratory movement in British Columbia. The specimens examined probably reflected the activities of museum collectors to at least as great an extent as they did changes in the activity of the bats. Much of southwestern British Columbia appears to offer a climate suitable for hibernation of Silver-haired Bats, and winter records are known from Vancouver Island and Vancouver (Cowan and Guiguet 1965, Figure 2). There is little evidence of regional segregation of the sexes in the province. All four specimens collected in June in northeastern British Columbia were females; however, unlike the remainder of the province, the region is geographically, and probably ecologically, like much of Alberta.

Sex ratios of adult specimens from southwestern British Columbia were approximately equal from at least May through September. The general overlap of winter and maternity ranges was demonstrated by the occurrence of juveniles on Vancouver Island 13 June 1975, in Vancouver 30 June 1971, and of a young individual in the Okanagan region on 16 July 1938 (Figure 1).

Regular occurrence of adult male Silver-haired Bats in the maternity range of the species is not known by us to occur elsewhere. Altitudinal, rather than latitudinal, migration in British Columbia possibly occurs; however, insufficient specimens are available with accompanying altitudinal data to examine this possibility realistically. Alternatively, southwestern British Columbia may present an environment that does not necessitate segregation of the sexes.

Acknowledgments

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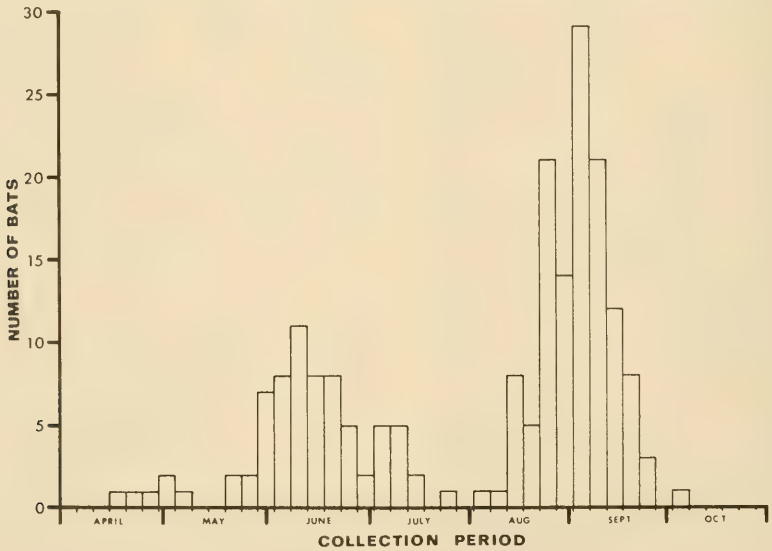

FIGURE 3. Collection of rabies-suspect Silver-haired Bats by 5-d periods from Alberta, 1974 to 1976 (updated from Dorward et al. 1977).

appreciated. Personnel at the Provincial Museum of British Columbia, the Ian McTaggart Cowan Museum at the University of British Columbia, and the Zoology Museum at the University of Alberta provided access to their collections. We gratefully acknowledge the cooperation of J. Bradley and the laboratory assistance of H. Boumans, B. Prins, and D. Meyer, all of ADRI(W). A. Todd and L. Harder kindly reviewed drafts of this manuscript.

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Large-flowered Trillium, *Trillium grandiflorum,* in Nova Scotia[1]

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Nickerson, N. L. and I. V. Hall. 1978. Large-flowered Trillium, *Trillium grandiflorum,* in Nova Scotia. Canadian Field-Naturalist 92(3): 291.

In Canada, *Trillium grandiflorum* (Michx.) Salisb. has been reported only from Ontario and Quebec (Fernald 1950; Marie-Victorin 1964). A single specimen (CAN 14631) was collected in 1883 by Macoun at Truro, Nova Scotia, but this was thought to have been planted there (W. J. Cody, personal communication). The species was not included by Roland and Smith (1969) in their treatment of the flora of Nova Scotia.

On 21 May 1976, we observed *Trillium grandiflorum* in flower on a 15-m south-facing bank of a small wooded ravine at Centreville, Kings County, Nova Scotia (45°08′N, 64°32′W). There were 16 clumps scattered over an area of approximately 5 m^2. The largest clump contained 16 flowering stems, three clumps contained 3 to 6 stems each, and the other consisted of 1 or 2 stems each. The soil in the area was a clay loam. The predominant tree was *Fraxinus americana* (White Ash), the leaves of which were just beginning to unfold. Other woody species in the area were *Amelanchier laevis* (Serviceberry), *Acer saccharum* (Sugar Maple), and *Sambucus pubens* (Red-berried Elder). The ground-story species were *Equisetum arvense* (Field Horsetail), *Matteuccia struthiopteris* var. *pensylvanica* (Ostrich Fern), *Erythronium americanum* (Dog's-tooth Violet), *Smilacina racemosa* (False Spikenard), *Rubus strigosus* (Wild Raspberry), and *Aralia nudicaulis* (Wild Sarsaparilla). Scattered flowering stems of the purple-flowered form of *Trillium erectum* (Purple Trillium) were also observed several metres from the clumps of *T. grandiflorum.* We found no evidence to suggest that *T. grandiflorum* had ever been planted in this area. The site represents a range extension of approximately 550 km for the Large-flowered Trillium. Collections of this species from the Centreville site have been deposited in the herbaria of Acadia University (ACAD 005215, 005216) and of Agriculture Canada, Ottawa (DAO 156597).

We thank R. J. Newbery for bringing the Centreville site to our attention.

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[1]Contribution #1633 of the Research Station, Kentville.

Twinning in Dall Sheep

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Hoefs, M. 1978. Twinning in Dall Sheep. Canadian Field-Naturalist 92(3): 292–293.

During an Elk investigation carried out by the Yukon Game Branch an observation was made of a Dall Sheep *(Ovis dalli dalli)* ewe with two lambs. This appears to be a true instance of twinning. The observation was made on 20 May 1977, on a mountain along the Nordenskjold River, some 100 km NW of Whitehorse, Yukon Territory.

The Yukon Game Branch maintained a field camp in the area from 20 May to 13 June 1977, during which time these sheep were kept under observation. The following circumstances lead me to assume that this is a true instance of twinning in Dall Sheep.

The ewe and the two lambs were observed on 20 May, which is the peak lambing period in the southern Yukon (Hoefs 1975), in isolation from other sheep. No other nursery sheep were observed during our survey, and the nearest rams were 1 km away. Ewes are known to separate from nursery bands a few days prior to giving birth and to rejoin the bands when their new-born lambs are 2–3 days old. Both lambs still had the "dirty-gray" color characteristic of Dall Sheep lambs during the first few days of life (Figure 1). Both lambs were observed to nurse, which had never been documented in "baby-sitting" situations: a ewe only allows her own lamb to suckle. Both lambs were observed to stay with the ewe after the group had joined a nursery band.

There is so far no conclusive evidence of twinning in Dall Sheep. Although a few investigators state that twinning may occasionally occur (Dixon 1938; Murie 1944; L. J. Palmer 1941, USA Fish and Wildlife Service unpublished report), detailed population studies have not documented it (Alaska Department of Fish and Game unpublished reports by F. Jones 1963, M. Pitzman 1969, L. Nichols and W. Heimer 1972; Luckhurst 1973). W. Heimer, Alaska Fish and Game Department (personal communication) collected 43 ewes in various areas of Alaska and N. Simmons, Northwest Territories Fish and Wildlife Branch (personal communication) collected 107 ewes in the Mackenzie Mountains of the Northwest Territories. Inspections of the embryos did not reveal any twins. During the past 10 yr I have monitored the lambing period of the Dall Sheep population on Sheep Mountain in Kluane National Park. Over 400 newly born lambs were observed and all were singles

FIGURE 1. Dall Sheep ewe with two newly born lambs, assumed to be twins.

(Hoefs 1975, and unpublished data). Over the past 10 yr 50 single Dall Sheep lambs were born at the Yukon Game Farm. Better nutrition of these captive sheep has resulted in earlier sexual maturity, and increases in body size and horn growth. Supplementary feeding during ovulation time (a practice referred to as "flushing" in animal husbandry), however, did not result in twinning.

It must therefore be concluded that twinning is extremely rare in Dall Sheep and that nutrition or range condition has little or no influence on it.

I am grateful to the following Yukon Game Branch staff members for assisting with these observations: W. Klassen, G. Lortie, and J. McDonald.

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Status of the Peregrine Falcon, *Falco peregrinus*, in the Central Kuskokwim River Region, Alaska

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Ritchie, Robert J. and Robert E. Ambrose. 1978. Status of the Peregrine Falcon, *Falco peregrinus*, in the central Kuskokwim River region, Alaska. Canadian Field-Naturalist 92(3): 293.

The potential for nesting Peregrine Falcons, *Falco peregrinus*, on the Kuskokwim River, Alaska, has been discussed with optimism (Cade 1960; Fyfe et al. 1976). Apart from the reports of Hinkley (1900), who noted them as common, however, there are few records for peregrines for this drainage (Dice 1920; Cady et al. 1955). More recently, peregrines have been observed near McGrath (J. McGowan, personal communication) and they are known to occur along tributaries of the lower Kuskokwim (C. White, personal communication).

Between 23 July and 3 August 1976, we traveled along the Kuskokwim River, from McGrath to Aniak, a distance of approximately 460 river km. Thirty-four series of cliffs were mapped and examined for raptor use. Peregrine Falcons, two lone adults and a pair with one recently fledged young, were observed at three of these cliffs, where none had previously been recorded. Besides peregrines, Red-tailed Hawks, *Buteo jamaicensis*, and nesting Rough-legged Hawks, *Buteo lagopus*, were observed and noted to be common near these cliffs.

It is unlikely that the central Kuskokwim River ever supported a large population of Peregrine Falcons. Data from our survey (the time of which reduced opportunities to observe all peregrines, including those whose nesting attempts had already failed), however, suggests the potential for at least a few pairs between the Swift Fork and Aniak (approximately 250 river km). Along this portion of the Kuskokwim, cliff habitat is similar to peregrine habitat along the upper Yukon River near Circle, Alaska. Cliffs are noticeably limited in size and number on the rest of the river surveyed and probably would support only an occasional pair.

We acknowledge the logistic support of Pete Shephard, Alaska Department of Fish and Game, McGrath, and Sigurd Olson and Hatch Graham, United States Forest Service, Anchorage.

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Status of the Osprey in Antigonish County, Nova Scotia

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Prévost, Yves A., Robert P. Bancroft, and Norman R. Seymour. 1978. Status of the Osprey in Antigonish County, Nova Scotia. Canadian Field-Naturalist 92(3): 294–297.

Information on Osprey (*Pandion haliaetus*) reproductive success in Antigonish County, Nova Scotia, is reported for 19 occupied nests in 1975 and 22 in 1976; 1.16 young per occupied nest were raised in 1975 and 1.19 in 1976. Nesting success on utility poles and natural sites is comparable. Limiting factors included distance from coast, weather conditions, and human interference. The population appears to be reproductively stable.

Key Words: *Pandion haliaetus*, reproductive status, Nova Scotia.

Considerable attention has been paid to the Osprey (*Pandion haliaetus*) since the decline of many populations in North America became apparent about 15 yr ago (Henny 1977). Godfrey (1970) listed the Osprey among Canada's endangered birds and noted that it was declining over much of its range. In 1974 and 1975, the Canadian Wildlife Service conducted extensive surveys of raptorial birds in the Maritime Provinces (R. F. Stocek, unpublished). There is still relatively little known about population stability of Ospreys in eastern Canada, and no nesting studies nearer than Connecticut (Ames and Mersereau 1964) and Labrador (Wetmore and Gillespie 1976) are known to us.

This paper reports on aspects of the natural history and reproductive success of an Osprey population in Antigonish County, Nova Scotia. The population was noted in 1957 (A. J. Erskine, unpublished), and is undoubtedly long established. Data were gathered on breeding pairs, nest sites, and reproductive success during an intensive study of Osprey feeding ecology in 1975 and 1976. Incidental data from 1972 to 1974 are also included.

Study Area and Methods

The highlands of Antigonish County are covered with broad-leafed and mixed forests, while valley slopes and poorly drained areas are mainly forested with conifers. Lakes, streams, and rivers flow into shallow estuaries rich in marine life. Dairy farming is the main agricultural activity. Clear-cutting of conifers is extensive.

We located nests by enquiries of local residents, by observing birds returning to nests from foraging areas, and by searching from helicopters and fixed-wing aircraft. Aerial surveys of nest sites were made on 20 May; 10, 11, 12 June; 30 July 1975; and on 2 June and 21 July 1976. Eggs and nestlings were counted mainly from helicopters. We believe that we located most nests in the study area. Enclosed blinds approximately 200 m from nest sites were used during periods of observation. Care was taken to minimize disturbance during regular ground visits to the nests to collect food remains.

Results and Discussion

Breeding Chronology

Ospreys were first seen on the study area in mid-April (17, 19, 20, 21, and 16 April, respectively from 1972 to 1976). Suitable feeding locations were sometimes covered with ice when the birds arrived, but most were free of ice within 2 wk. Dates of arrival were probably not directly linked to spring thaw. Even in 1976 when all foraging locations were ice-free in late March, Ospreys did not arrive until mid-April.

Repair of old nests and construction of new nests began within a few days of arrival. Copulatory behavior was observed as early as 23 April in 1975 and each year continued throughout the egg-laying period. There was a delay of approximately 2 wk between spring arrival and the onset of egg laying. The first egg in five nests was hatched by 11 June in 1975. Apparently at least one young hatched in all nests by 20 June in 1975 and 1976.

By mid-August adults and most young had left the nest sites, but some young were seen near nests 40 d after fledging. Birds appeared to range widely before leaving the study area in mid- to late September.

Nest Sites

Four of 26 nests (Figure 1) were in dead trees along river bottoms and five in upland conifers. The remainder were located on utility poles along power lines (Figure 2). The double T design of the utility poles seemed to provide excellent support for nests. Although Ospreys usually nest near water (Bent 1937; Brown and Waterston 1962), only four of our nests were within 3 km of large bodies of water.

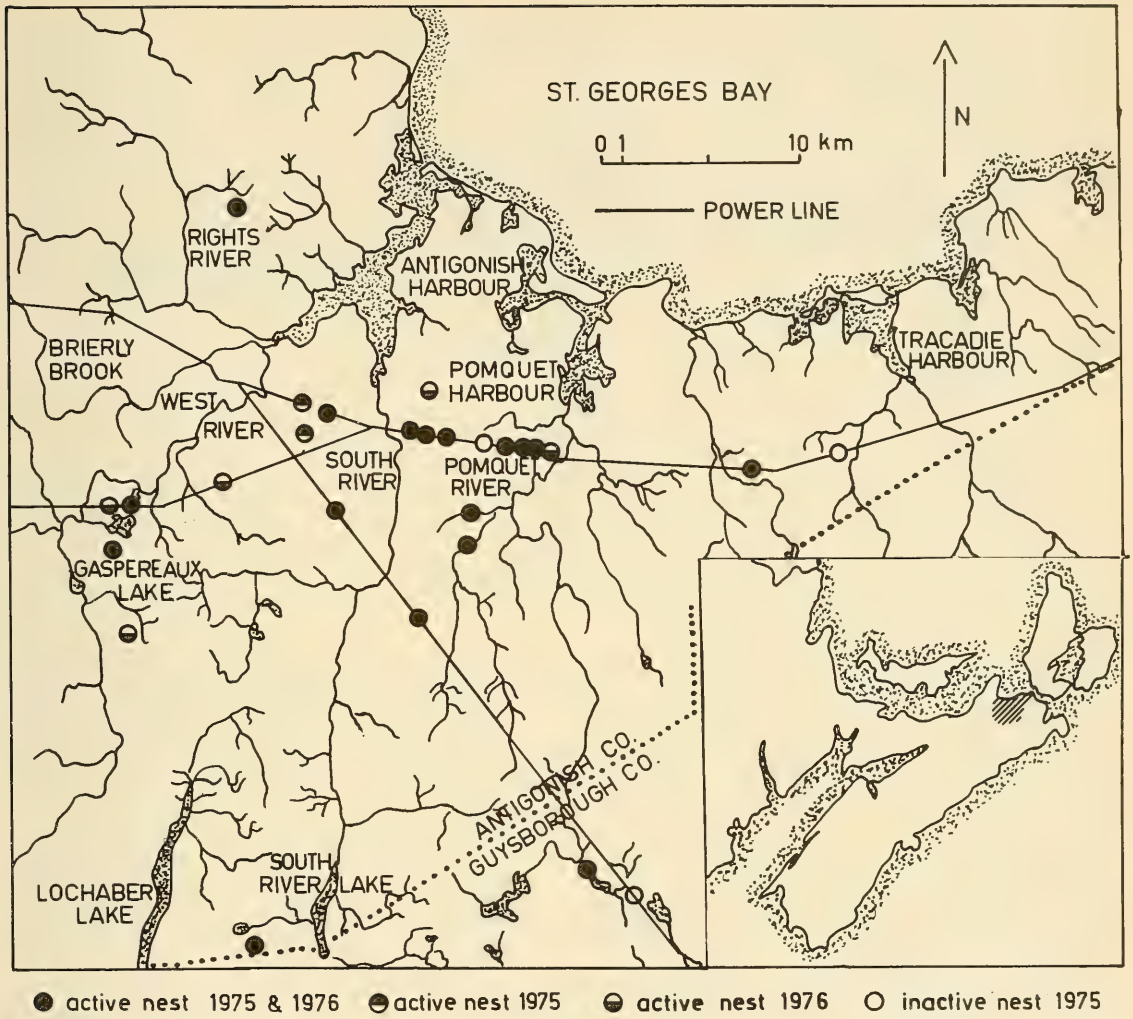

FIGURE 1. Locations of Osprey nest sites in Antigonish County, Nova Scotia, in 1975 and 1976. The shaded area in the insert shows location of the study area in Nova Scotia.

The occurrence of Osprey nest sites on utility poles is widespread (Strom-Gotsa *in* Brown and Waterston 1962; Ames 1964; Schroeder 1972; Melquist 1974), and happens in neighboring New Brunswick(Stocek 1972) and elsewhere in Nova Scotia (unpublished data). In our study area, Ospreys seemed to prefer these sites, perhaps because intensive cutting of the forest has reduced natural alternatives. In both years the closest natural nest sites were 2 km apart. In contrast, five nests in 1974, six in 1975, and seven in 1976 were found along one 3-km segment of power line; four of these nests were on one 800-m segment in 1976. Prévost, Seymour, and Titman (in preparation) provide evidence of social foraging in Ospreys, a behavior that may be facilitated by nesting in colonies. Power lines apparently provided the most favorable locations for colonial nesting in northeastern Nova Scotia.

Reproductive Success

The mean clutch and brood sizes were 2.61 and 2.2 in 1975, and 2.95 and 2.3 in 1976. Clutch size distribution for both 1975 and 1976 combined was (clutch size-number of nests) 1-4, 2-9, 3-16, and 4-9.

The success rates of 41 occupied nests (with additional data from adjacent Pictou County) in 1975 and 1976 are shown in Table 1. A hurricane late in the nestling period of 1975 (28 July) dislodged three nests from utility poles and probably killed the young. Another nest was blown from a tree, but the two

FIGURE 2. Osprey nest on utility pole, Antigonish County, Nova Scotia, 1976.

nearly full-grown young fledged nonetheless. Three young from a nest toppled by wood cutters in 1975 (21 July) presumably died. In 1976, one active nest was destroyed by a forest fire that burned several thousand acres of potential nesting habitat. During 1976, seven nests were abandoned at various stages of incubation, one after 60 d.

Henny and Wight (1969) suggested that a recruitment of between 0.95 and 1.30 young per active nest was needed to maintain a stable population. Postupalsky (1974) urged that estimates of Osprey production be based on all occupied nests. Our results are based on occupied nests since we could not be sure whether eggs had been laid and later disappeared. The average productivity on utility poles and natural nest sites was 1.22 and 1.08 respectively.

Limiting Factors

In July anadromous fish in the rivers became less available, and the Ospreys shifted their hunting to coastal estuaries, where Winter Flounder (*Pseudopleuronectes americanus*) became the main food

TABLE 1—Reproductive success of ospreys in Antigonish County, Nova Scotia, on utility poles and natural sites[1]

		Nests found	Occupied nests	Active nests	Productive nests	Young raised	Young/occupied nest (known outcome)
1975	Utility poles	15	12	12	5	13	1.08
	Natural sites	7	7	6	5	9	1.29
	Total	22	19	18	10	22	1.16
1976[2]	Utility poles	14 (17)	14 (17)	12 (15)	9 (10)	19 (22)	1.36 (1.29)
	Natural sites	8 (9)	8 (9)	7 (8)	2 (3)	6 (7)[3]	.86 (.88)[3]
	Total	22 (26)	22 (26)	20 (24)	11 (13)	25 (29)[3]	1.19 (1.16)[3]
Total		44 (48)	41 (45)	38 (42)	21 (23)	47 (51)[3]	1.18 (1.16)[3]

[1]Terminology follows that of Postupalsky (1974), but with slight modifications. An occupied nest was a nest attended by two birds early in the season. An active nest was an occupied nest in which eggs were seen or from which the female did not flush during the first survey. A productive nest was a nest in which young were present during the second (nestling) survey.

[2]Figures in parentheses refer to data from Antigonish County together with additional data from adjacent Pictou County.

[3]Does not include an occupied nest for which the count of young raised was unavailable.

supply (Prévost and Newsome, in preparation). Ospreys nesting inland then had farther to fly for food. Nests closer to the coast were more successful in 1976, but the data are too few to be conclusive.

Human encroachment, the widespread practice of beaver-dam removal, and the overcut state of Antigonish County forests (N.S. Department of Lands and Forests, unpublished data) have presumably decreased the number of available natural nest sites.

Breeding success is directly influenced by high winds, particularly where nests are located on dead trees and utility poles. Weather patterns may also indirectly influence breeding success by affecting prey accessibility and hence the foraging efficiency of individuals (unpublished data). This could be critical early in the nestling stage.

Birds in this population may be exposed to toxic chemicals during migration, but they are unlikely to become contaminated on the breeding ground. Agricultural activities are mostly limited to haymaking and pasturing of dairy cattle and do not usually involve extensive use of pesticides. Northeastern Nova Scotia forests have never been extensively sprayed.

Human activity may be a significant mortality factor. In addition to the case of mortality (nest tree felled) already mentioned, two marked and banded young Ospreys were shot before they migrated south in 1976. Several other Ospreys and Bald Eagles (*Haliaeetus leucocephalus*) were known to have been shot in the study area and elsewhere in the county during the study period. We believe that disturbances at easily accessible nests were responsible for the failure of some nesting attempts. Power companies or local company supervisors in some areas of the Maritime Region have a policy of nest removal from utility poles (Stocek, unpublished data).

Population Estimates

The size of the Osprey population in Antigonish County is presumably related to the availability of adequate food and nesting sites. We have located some nests in adjoining Guysborough and Pictou Counties, and observations at foraging locations there suggest concentrations of nesting Ospreys similar to that found in our study area. Similar habitat occurs in nearby areas that have not yet been surveyed. Only an intensive survey can provide an accurate estimate of breeding pairs. From the results of ground observations and aerial surveys we conclude that there were at least 30 occupied nests in Antigonish County in 1975 and 1976. This population is relatively large, and its measured recruitment suggests stability. It is possible that it has not experienced the depletion of numbers and the decline in productivity observed elsewhere (Henny 1977).

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Alf Erling Porsild

Photograph taken in 1959 by H. M. Raup on an aircraft during the arctic field trip of the IX International Botanical Congress.

ALF ERLING PORSILD, M.B.E., F.R.S.C.
(1901–1977)

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Alf Erling Porsild was born in Copenhagen, Denmark, 17 January 1901, and died while visiting Vienna, Austria, 13 November 1977. His ashes will be taken to Disko, Greenland, for burial in the family plot, close to the areas where he spent his youth and first acquired an interest in the northern flora.

Porsild received his early education in Greenland but was later sent to a boarding school in Denmark. He obtained his Ph.D. degree from the University of Copenhagen in a very unusual way. His book entitled *The Vascular Plants of the Western Canadian Archipelago* (1955) was accepted as a thesis by the university, an incredible honor.

During the years 1922–1925 he was assistant botanist at the Danish Biological Station, Disko, Greenland, the station established and directed by his father, Morten Pedersen Porsild. It was there, also, that Erling's brother, Robert Thorbirn Porsild, did his first botanical collecting. (On 30 December 1977, Robert Porsild died at Whitehorse, Yukon Territory.)

In 1926 Erling Porsild entered the service of the Government of Canada as a botanist. He was immediately placed in charge of reindeer-grazing investigations in Alaska and Arctic Canada, which eventually led to the establishment, under his direction, of the Reindeer Experiment Station on the east branch of the Mackenzie Delta. His botanical surveys through ten summers and seven winters took him by canoe and dog team from the Richardson Mountains west of the Mackenzie River Delta eastwards to the Coppermine River, about Great Bear Lake, and in 1930 to central District of Keewatin. In 1927 and 1928 he was accompanied by his brother, R.T. Porsild. His longest trip was on a survey of winter grazing conditions for reindeer along the west and north coasts of Alaska, from Nome, Alaska, to Aklavik in the Mackenzie River Delta, Northwest Territories. As a result of these surveys and subsequent recommendations, the Canadian Government purchased a herd of reindeer in Alaska. These animals were driven from Alaska to the east branch of the Mackenzie River Delta where 2370 were delivered in March 1934. They were introduced into Canada primarily for the benefit of the Canadian Eskimo, and for this reason Porsild journeyed to Lapland in 1931 to hire young reindeer herders to teach the Canadian Eskimo the art of reindeer herding.

Incidental studies of the native flora and fauna, as well as of geographical features, made by Porsild during this period, resulted in large numbers of specimens of plants and animals being incorporated into the collections of the National Museum. Another outcome was a series of published papers on the Canadian North, not only about plants, but also reindeer, the native people, birds, mammals, and physiographic features.

In 1933 M. O. Malte, Chief Botanist of the National Museum of Canada, died. In 1936, after his return from the north, Erling Porsild was appointed Acting Chief Botanist. He left Ottawa, however, in May 1940, to assume the post of Canadian Vice-Consul to Greenland and subsequently spent most of his time in Greenland as Canadian Consul until November 1943, when he resumed full-time duties at the Museum in Ottawa. He became Chief Botanist in the National Herbarium in 1946, a position which he held until his retirement in January 1967. This position involved responsibility for the maintenance and development of the National Herbarium and for botanical field work and laboratory studies conducted by the staff or otherwise sponsored by the National Museum. For many years the staff of the National Herbarium was small and only the vascular plants received adequate attention. In the early 1950s a Curator was appointed to work on lichens and mosses, and in 1966 another was appointed to work on algae. It then became possible to assimilate the backlog of specimens in these other groups collected by John Macoun and accumulated by exchange with other institutions. As a result, from the time of his appointment in 1936 to his retirement in 1967, the numbered collections in Porsild's care grew from 120 000 to just over 430 000 specimens. The bulk of these specimens was still the vascular plants (70%), about one quarter was mosses (24%), and the balance lichens (5%) and algae (1%). Porsild's personal collections aggregated 25 000 numbers and resulted in well over 100 000 herbarium specimens, the first set being in the National Herbarium of Canada (*CAN*) and many hundreds of duplicates deposited in various major herbaria of the world.

After his reindeer work, Porsild's field studies took him to botanically unknown and interesting regions: to Labrador (1937), west Greenland (1940–1943),

Alaska and the Yukon (1944), Siberia and Russia (1945), Rocky Mountains in Alberta (1945–1946, 1951, 1955–1960), Hudson Bay Lowlands (1956–1957), Mackenzie River (1947), Banks and Victoria Islands (1949), Axel Heiberg Island (1953), western United States (1948, 1961) and Mexico (1963). In 1959 he organized and led botanical excursions to the Rocky Mountains and to the Canadian Arctic in connection with the IX International Botanical Congress held in Montreal. In addition, visits to the United States and various countries in Europe enabled him to study specimens in nearly all the leading herbaria possessing important collections of arctic and boreal plants.

From 1920 to 1977, over one hundred publications appeared under the name of A. E. Porsild, as well as several others of which he was co-author (see pages 301–304). Major publications of book length dealt with the floras of Alaska, the Yukon, the Northwest Territories, and the Rocky Mountains. One of the most recent was a detailed report of collections made by his brother, R. T. Porsild, from the Ogilvie Mountains in central Yukon Territory. Unfortunately, his last major work, a large manuscript on the flora of the continental Northwest Territories, written with W. J. Cody of the Biosystematics Research Institute, Agriculture Canada, had not reached the production stage at the time of his death.

Porsild's collections included about eighty plant taxa new to science, most of which he personally described and published. The list includes *Aconitum delphinifolium* DC. var. *albiflorum* (28),* *Antennaria alborosea* (67), *A. Breitungii* (67), *A. crymophila* (40), *A. densifolia* (45), *A. elegans* (67), *A. Ellyae* (126), *A. glabrata* forma *ramosa* (5), *A. incarnata* (67), *A. Laingii* (31), *A. neoalaskana* (40), *A. pedunculata* (67), *A. philonipha* (31), *A. pulcherrima* var. *angustisquama* (67), *A. Rousseaui* (63), *A. shumaginensis (66), A. stolonifera* (67), *Arctagrostis latifolia* ssp. *nahanniensis* (98), *Arenaria obtusiloba* forma *rosea* (31), *Arnica alpina* forma *inundata* (5), *Aster elegantulus* (69), *Calamagrostis chordorrhiza* (40), *C. lapponica* var. *nearctica* (40), *C. Robertii* (126), *Cardamine bellidifolia* var. *beringensis* (28), *Carex atrofusca* var. *decolorata* (40), *C. elynaeformis* (40), *C. kokrinensis* (31), *C. maritima* ssp. *yukonensis* (113), *C. melozitnensis* (31), *C. Morrisseyi* (40), *C. rariflora* var. *androgyna* (40), *Claytonia Bostockii* (75), *Corydalis pauciflora* var. *albiflora* (75), *Draba yukonensis* (12), *Dryas alaskensis* (54), *D. drummondii* var. *eglandulosa* (107), *Erigeron grandiflorus* ssp. *arcticus* (126), *Eriophorum opacum* var. *cinnamomeum* (36), *Gentiana Raupii* (40), *G. Richardsonii* (75), *Hieracium gracile* var. *yukonense* (69), *Kobresia arctica* (40), *Lomatogonium rotatum* ssp. *tenuifolium* forma *albiflorum* (126), *Melandrium apetalum* ssp. *ogilviense* (126), *M. macrospermum* (31), *M. Ostenfeldii* (40), *Oxytropis glutinosa* (75), *O. Huddelsonii* (75), *O. hyperborea* (40), *O. Jordalii* (80), *O. kokrinensis* (31), *O. Koyukukensis* (80), *O. sheldonensis* (75), *O. verruculosa* (75), *O. viscidula* ssp. *sulphurea* (75), *Papaver alaskanum* forma *stenopetalum* (126), *P. Keelei* (45), *P. Walpolei* (31), *Parrya arctica* forma *albiflora* (90), *Pedicularis lanata* ssp. *yukonensis* (126), *Penstemon Gormannii* forma *albiflora* (75), *Petasites arcticus* (40), *Poa ammophila* (40), *P. Jordalii* (107), *Polygonum viviparum* var. *paniculata* (5), *Potentilla furcata* (75), *P. nivea* ssp. *fallax* (75), *P. pulchella* var. *gracilicaulis* (40), *Primula tschuktschorum* ssp. *tschuktschorum* var. *beringensis* (107), *P. tschuktschorum* ssp. *Cairnesiana* (107), *P. ludoviciana* forma *glabrata* (126), *Saussurea angustifolia* var. *yukonensis* (45), *Senecio sheldonensis* (69), *S. yukonensis* (69), *Taraxacum mackenziense* (125), *T. pellianum* (69), *Thlaspi arcticum* (40), *Trisetum spicatum* forma *viviparum* (126). In addition to the above, one species was described jointly with Harold A. Senn: *Agropyron teslinense* (75), a second with Gerald A. Mulligan: *Lesquerella Calderi* (121), and the following new names were proposed: *Antennaria Böcheriana* (108 — for *A. canescens* var. *pseudoporsildii* Böcher), *A. Ekmaniana* (40 — for *A. angustifolia* E. Ekman), *Kobresia hyperborea* (75 — for *K. arctica* Porsild, not *K. arctica* Ivanova), *Dryas Babingtoniana* (94 — for *D. octopetala* β *pilosa* Bab.), *Potentilla Ledebouriana* (75 — for *P. uniflora* Ledeb.), *Senecio Kjellmannii* (31 — for *Cineraria frigida* Richards. forma *tomentosa* Kjellm., not *Senecio tomentosum* Michx.), *Silene obovata* (23 — for *Anotites latifolia* Greene, not *Silene latifolia* (Mill.) Britten & Rendle).

Porsild named *Calamagrostis Robertii* in honor of his brother and in turn was honored by botanists naming the following plants for him: *Arnica Porsildiorum* Boivin, *Carex capillaris* var. *Porsildiana* Polunin, *Eriophorum* × *Porsildii* Raymond, *Draba Porsildii* G. A. Mulligan, *Lupinus Porsildianus* C. P. Smith, *Papaver lapponicum* ssp. *Porsildii* Knaben, *Picea glauca* var. *Porsildii* Raup, *Poa Porsildii* Gjaerevoll, *Potamogeton Porsilidiorum* Fernald, and *Saxifraga punctata* ssp. *Porsildiana* Calder & Savile, *Smelowkia calycina* var. *Porsildii* Drury & Rollins; also the genus *Porsildia* Löve & Löve. *Antennaria Porsildii*, *Mielichhoferia Porsildii* Hagen, and *Puccinellia Porsildii* Th. Sörensen were named after his father, Morten P. Porsild.

During his botanical career, Porsild received numerous honors and awards, including a scholarship from the American Philosophical Society (1954) and a

*The numbers in parentheses refer to the items in the list of publications.

Guggenheim Memorial Foundation Fellowship (1957–1958). He was elected a Fellow of the Royal Society of Canada in 1946; Fellow of the Arctic Institute of North America (1946); Fellow of the Swedish Phytogeographical Society, Uppsala (1958); Honorary Fellow of the American Academy of Arts and Sciences (1947), of the Societas pro Fauna et Flora Fennica (1948), Societatis Zoologica-botanica, Vanamo (1948), of the Finnish Academy of Science (1957), and the Norwegian Academy of Sciences (1964). For his services as a civilian during the Second World War, Porsild received membership in the Order of the British Empire (M.B.E.). In 1966 he was given a Massey Medal for his distinguished contributions to arctic botany and to the Canadian scientific community. In 1971 the Botanical Society of America bestowed on him its annual Merit Award, and in the same year the Canadian Botanical Association presented him with its Lawson Medal for notable contributions to the advancement of Canadian botany. In 1967, Acadia University conferred on him an honorary Doctor of Science degree in recognition of his remarkable achievements. In 1973 another honorary Doctor of Science degree was given to him by the University of Waterloo. In 1971 The Ottawa Field-Naturalists' Club made him an Honorary Member for, in addition to his many accomplishments as a scientist, he was a member of Council of that organization for many years, served as Chairman of the Publications Committee for several years, and was President of the Club for the years 1939 and 1940.

Erling Porsild was a quiet and reserved man with a droll sense of humor and a strong love for the out-of-doors. He had many friends both in Canada and abroad. Common interests in the North led to the formation by a group of people in the Ottawa area of "The Arctic Circle" and Porsild was elected president of the newly formed society in January 1948. In his work at the Museum, Porsild managed the Herbarium with the minimum amount of time spent on administrative matters and so was able to devote himself almost exclusively to field work, herbarium research, and writing.

He is survived by his wife Margrit and by two daughters, Mrs. Karen Lumsden of Toronto, Mrs. Toni Kluth of England, a brother Sten Porsild, and a sister Asta Egede, both in Denmark.

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News and Comment

Notice of Change to the By-laws of The Ottawa Field-Naturalists' Club

Changes to By-laws 6 and 9 of The Ottawa Field-Naturalists' Club were passed unanimously by the Council at the meeting of 12 June 1978. These By-laws now read as follows:

6. *Duties of the Publications Committee*
The Publications Committee shall act in an advisory capacity to the Council in all matters pertaining to the publications of the Club. It shall recommend an Editor and a Business Manager for each publication, as required, for appointment by Council. It shall, in consultation with the Editor, appoint Associate Editors for each publication, as required.

9. *Duties of the Editors*
The Editor of each publication shall be responsible for the editorial policy, content, and preparation of that publication; shall be a member of the Publications Committee; and shall keep the Publications Committee informed regarding the publication. The Associate Editor(s) of each publication shall assist the Editor.

DIANA R. LAUBITZ,
Recording Secretary

Notice of a Motion to Amend the Constitution of The Ottawa Field-Naturalists' Club

Notice of a motion to amend the Constitution of The Ottawa Field-Naturalists' Club was received, in accordance with Article 23 of the Constitution, for presentation at the next Annual Business Meeting. It is proposed that:

Article 3, Item (3), now reading:

"SUSTAINING MEMBERSHIP. A person or family shall be granted a Sustaining Membership upon payment of an annual fee of $25.00."

and Article 3, Item (4), now reading:

"LIFE MEMBERSHIP. A person shall be granted a Life Membership upon payment of a fee of $200.00 in a single payment for such a membership."

be amended to read as follows:

(3) SUSTAINING MEMBERSHIP. A person or family shall be granted a Sustaining Membership upon payment of an annual fee, the amount of which shall be set out in the By-laws.

(4) LIFE MEMBERSHIP. A person shall be granted a Life Membership upon a single payment of a fee, the amount of which shall be set out in the By-laws.

Motion proposed by Ellaine Dickson, seconded by Roger Taylor.

Diana R. Laubitz,
Recording Secretary

Call for nominations for the Council of The Ottawa Field-Naturalists' Club

A Nominating Committee has been chosen by the Council to nominate persons for election to offices and membership of the Council for the year 1979, as required by the Constitution.

Club members may also nominate candidates as officers and other members of Council. Such nominations require the signatures of the nominator and seconder, and a statement of willingness to serve in the specified position by the Nominee. Nominations should be sent to the Nominating Committee, The Ottawa Field-Naturalists' Club, Post Office Box 3264, Postal Station C, Ottawa, Ontario K1Y 4J5, to arrive no later than 15 November 1978.

The Committee will also consider any suggestions for nominees which members wish to submit to it by 1 November 1978. It would be helpful if some relevant background on the proposed nominees were provided along with the suggested names.

EWEN C. D. TODD
Chairman, Nominating Committee

Request for Information — Color-marked Purple Martins

A large-scale continent-wide Purple Martin color-marking project was initiated in 1977. Observers are asked to look for and report any color-marked (plastic leg bands and/or wing tags) Purple Martins. Please record the color of the bands or wing tags, which leg they are on, age and/or sex (if either is known), where and when observed, and whether the bird was in a roost, staging flock, migratory flock, or at a nest site (scouting or nesting?). We are especially interested in the movements of young birds and their return to the parent colony or nearby colonies. All reports will be acknowledged and should be sent to *Kathleen Klimkiewicz, Bird Banding Laboratory, Laurel, Maryland 20811.*

Entomological Society of Canada Annual Meeting

The eighth annual meeting of the Entomological Society of Canada will be held 20–23 August 1978 in Ottawa. The program committee has encouraged amateur naturalists to participate in the photo salon and the poster session. There will be a public showing of all submitted photos and a slide show during the meetings. For further information please contact Ms. Suzanne Allyson, Biosystematics Research Institute, K.W. Neatby Building, Agriculture Canada, Ottawa, Ontario K1A 0C6 (or phone 613-994-9733).

IUCN Marine Program

A Marine Program was launched a year ago by IUCN (International Union for Conservation of Nature and Natural Resources). It now has around 30 active projects plus several other projects ready to start or in the process of being developed. Much of the program is funded by the World Wildlife Fund (WWF).

The immediate objectives of the program are to safeguard the most vulnerable animals; conserve the most precious habitats; stimulate governments and intergovernmental bodies to act more vigorously and on a bigger scale; and generate public support for such action.

Since its early formulation, however, the program has also had a broader, more ambitious aim: the conservation of major marine processes. Major marine processes are defined as dynamic systems of linked feeding, resting, breeding and nursery areas, including the areas that supply them with nutrients and other essentials. In short, IUCN is interested in developing management methods that reflect the special continuities and divisions of the seas rather than the narrow interests of different economic sectors.

At the level of species management this has involved IUCN in the search for an alternative to maximum sustainable yield (MSY) and in a scrutiny of the models used to determine quotas for whales and seals. Both activities are in their early stages, but the latter has already led IUCN to criticize IWC's (International Whaling Commission) Sperm Whale model and to call for a reduced Harp Seal quota and a delay or even cancellation of the hunt so that a reliable census can be made.

Some comments by G. Carleton Ray, chairman of IUCN's Marine Steering Committee are of interest. He says that marine science lags decades behind terrestrial science, and marine conservation is minimal. Furthermore, he asks us to visualize a living community together with the non-living components of the environment in order to focus on the largest and most important functional unit of all — the ecosystem.

He states that it is the ecosystem process which we must protect and herein lies the challenge, especially in the sea where ecosystems are huge, where ocean currents create subtle boundaries and linkages, and where most species' populations are highly migratory during various phases of their life cycles, even to the extent that whole components of communities travel hundreds of miles in larval form. Species and habitats are the results of these processes — a difficult matter for traditional conservation to address. It is easy to excite interest in "endangered species", but who will get excited about "process conservation"?

Then he concludes, as many others have done before him, that conservation will fail in the end unless it stops treating problems piecemeal and starts treating the ecosystem whole.

From IUCN Bulletin New Series 9(1&2), 1978

Canadian Contributions to Earthwatch not Tax-Deductible

Correction to the News and Comment item "Earthwatch — offers field research to the public" published in *The Canadian Field-Naturalist* 92(1): 97, 1978.

Before going on a first Earthwatch excursion Marjorie C. Burns of Ottawa last July wrote to Revenue Canada to inquire about the deductibility of contributions and travel expenses from her income tax. Unfortunately the reply she received indicated that under the Canadian Income Tax Act (paragraph 100 (1) (a)) donations made by Canadian participants to Earthwatch do not at present qualify as income-tax deductions.

Correction

News and Comment. Canadian Field-Naturalist 92(2): 203, 1978

The name of the warbler now protected in Ontario was misspelled. It should have read Kirtland's Warbler (*Dendroica kirtlandii*).

Book Reviews

Zoology

Wild Mammals of New England

By Alfred J. Godin. 1977. Johns Hopkins University Press, Baltimore. (Canadian distributor Burns and MacEachern, Toronto). xii + 304 pp. $30.

With this book, we have the appearance of the first complete treatment of the biology of all New England mammals. Wildlife biologist Alfred Godin has assembled a large body of information on all of the native, introduced, and extirpated species of the region including 27 marine forms, several of which are known in New England only as infrequent stranded specimens.

Most of the book consists of species accounts which include material on the mammal's description, distribution (including a range map), ecology, behavior, and a list of specimens examined. Where appropriate, information on sex and age determination is also included. Each account is enhanced by an attractive pencil drawing of the species in a lifelike pose. Literature citations are included at the end of each chapter (one chapter for each order of mammals) with 10% of the more than 1200 references dated since 1970.

In addition to the species accounts, an introductory chapter discusses the general characteristics of mammals and includes a biological key for identification of the species included in the text. Except for a few couplets, the keys are based on the external morphology of the whole animal rather than on skull characteristics; skulls are described in the species accounts, however. Another chapter briefly treats New England forest types, land forms, and climate.

Generally, the accounts contain a balance between technical and non-technical information and are both informative and entertaining. They are complete and the information presented is accurate with only a few minor errors of content or proofreading. I did note several instances, however, where Godin makes definitive statements on topics that are actually rather controversial. For example, the author states that the cougar can be considered to be extirpated from New England. Although he bases this opinion on the information that no specimens have been taken in over 70 years, the persistent reported sightings of this species appear to warrant a more open approach.

Overall, as a compilation of what is known and what is not known about the natural history of New England mammals, this book is a significant contribution. Since many of the species discussed are found throughout the northeastern United States and Canada, the book will also be useful outside New England. Both the general reader and the more serious student of mammals will find much of interest in this volume.

David A. Lovejoy

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Guide to the Pigeons of the World

By Andrew McNeillie. 1976. Elsevier (Canadian distributor Burns and MacEachern, Don Mills). 160 pp., illus. Paper $5.95.

Pigeon Fanciers' Survey to Breeds of the World would be a title more appropriate to the contents of this book. Persons seeking information on all species of pigeons (Columbidae) must look elsewhere, such as Derek Goodwin's *Pigeons and Doves of the World* (British Museum, London, 1967). McNeillie's book is a survey of the major breeds of the Domestic Pigeon *(Columba livia).* Within many breeds there are so many recognized varieties that a comprehensive guide to them all would require a much larger volume. Hence this book is not a total success as a guide.

The book consists of six brief introductory chapters followed by a longer guide to pigeon breeds. The introductory chapters outline the history of the association of Man with *Columba livia* and discuss various aspects of breeding, showing, flying, and caring for pigeons. These chapters are fairly concise, yet reasonably comprehensive, although one must hunt through them to find coverage on some topics. For example, detailed instructions on washing a bird are given in the chapter on "Pigeon Showing," not in "The Care of Pigeons."

The breed guide is preceded by a helpful topography and three pages of diagrams illustrating different types of face, feet, head markings, and fancy feather structures. Without this series of illustrations the descriptions of breeds would be less clear, and two terms in particular would be a source of great confusion: the "cere" of ornithological literature is termed the "wattle," whereas the "eye ring" of bird books is called the "eye cere," usually shortened to "cere"!

The breed guide, constituting about two-thirds of

the book, is divided into four sections grouping breeds according to functional types rather than to relationships. In general, breeds and their varieties are discussed on one page with appropriate illustrations on the opposite page, although this varies slightly, and not all breeds mentioned are illustrated. Some varieties or subvarieties illustrated are not specifically mentioned in the text. The text contains a wealth of information on distinguishing various breeds and varieties, ideal features from a show viewpoint, known and suspected origins, and various historical comments. The illustrations by Johan Lentink, Stephen Cocking, and Graham Smith are satisfactory, but not exceptional.

In general, the book is well written, with few grammatical or factual errors. Variety is used throughout as a subdivision of breed, but the statement (p. 146) that Rollers are a type rather than a variety of Tumbler is not clarified further. On the same page "Tumbler family" is used in a context obviously at variance with zoological usage. On p. 131, a breed is given a distinct species name, *Columba affinis*. A few characters given, such as comparative size, are not very useful in identifying varieties without prior knowledge of one of them. Perhaps the most amusing statement in the book is that the breed Ptarmigan is named after a "grouse-legged game-bird" by the same name.

I could make several additional minor technical criticisms, but these do not detract seriously from the book. There are many interesting facts scattered throughout. I can think of no better illustration of the amount of genetic variation possible within a single species. There are 150 varieties of the breed Modena alone, and many varieties have changed remarkably since they were first bred. No wonder this species was so influential in the thinking of Charles Darwin!

The "bibliography" is really a list of old works on the Pigeon, and will be of interest primarily to enthusiasts of old literature.

In summary, I recommend this book for its illustration of possible variability within a species, or as a fascinating document of Man's interactions with a long domesticated bird. For a guide to the world's pigeons, one must seek elsewhere.

MARTIN K. MCNICHOLL

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Alberta Birds 1961–1970

By T. S. Sadler and M. T. Myres. 1976. Occasional Paper Number 1, Natural History Section, Provincial Museum of Alberta, Edmonton. $3.25.

The basic intent of this book is to provide a year-by-year summary of birds of Alberta during the decade of the 1960s with a particular emphasis on migration. It relies heavily on the many Bird Observation Record Cards which were submitted by over 200 Alberta observers during those years.

The first 35 pages are reserved for a discussion of the history of the project, bird highlights for those years, a synopsis of the decade's weather, and the listing of locations for sites mentioned in the text. The text commences with a brief overview of the decade, appropriate research studies on the species in question during these years, and a yearly summary of observations. This section is followed by a list of contributors, an extensive bibliography for the decade, and finally, indices.

I found the summary for each species to be perhaps the most valuable part of the book. If research was conducted on the species in question, the authors summarize that research and give reference to their excellent bibliography. The year-by-year listing of key dates (viz. migration and occurrences), however, is much less useful and at times misleading.

The authors have pointed out the inevitable inconsistencies which arise when data are collected in this manner; they could work only with whatever was available on observation cards and in literature. This led to large gaps in geographical representation. As reports are from so many observers, this also means that the consistency of reports reflects irregular periods of available time for observation and varying degrees of thoroughness and expertise. This rather hit-and-miss data collection causes serious problems in interpreting the occurrence lists. Does one record of Hammond's Flycatcher and a single nesting record of Great Horned Owl during the decade, for example, accurately reflect true status? Undoubtedly it does not. These data could have been utilized more effectively, in my opinion, by discussing occurrence dates as averages for the decade. The extremes could also be listed and the relative confidence of these averages discussed. With no way of evaluating the relative merit or significance of any particular occurrence, the year-by-year listings lose a great deal of value.

The report is a reasonably well-bound glued-spine paperback, with an attractive cover illustration of swans drawn by Ludo Bogaert. The text is typewritten and for the most part, easy to read. Several pages in

my copy were blurred and/or faded. This is evidence of the hastiness of printing (as is the spelling error on the first page of the book!). The objective of the series is apparently to produce such reports as these very quickly, acknowledging that more than the normally acceptable errors will result, so that their content can be used while the data are "hot news." That it took two years for this 'quick print' would seem to contradict the objective and makes the error less acceptable. The major problem in this regard arises with the index page references which do not correspond to the text page numbers. One must add 35 to all index page references to arrive at the correct page in the text! The authors have already published several disclaimers in Alberta publications regarding these publishers' production errors.

This is not a guide to the birds of Alberta. It will be of value to Alberta birders who already have a baseline knowledge of the province's avifauna. For new residents and/or visitors, reference to the recently released *Birds of Alberta* (Salt and Salt 1976) would be more appropriate and satisfying.

The authors of *Alberta Birds 1961–1970* have (rightly) expressed disappointment in the number of production errors in the book and with the great length of time taken for publication.

My personal disappointment would have been reduced significantly if the species accounts had been more decisive and informative. *Alberta Birds 1961–1970* was a good idea and I hope we will see other such good ideas in the future. Let us hope that subsequent reports have a more consistent data base from which to draw.

DANIEL F. BRUNTON

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Rocky Mountain Wildlife

By Don Blood, Tom. W. Hall, and Susan Im Baumgarten. 1976. Hancock House, Saanichton, British Columbia. 132 pp.

Rocky Mountain Wildlife is primarily a reference work intended for readers requiring a compact, easy-to-read compendium of information on the area's ecology, its spectacular mammals and birds, their habitats, social organization, and migratory patterns. The book is of the large format style and is liberally scattered with photographs and illustrations.

The Rocky Mountain area covered by this book includes the Cariboo, Purcell, and Selkirk Ranges in British Columbia, the Clearwater and Salmon River Ranges in Idaho, Uinta Mountains of northeastern Utah, and virtually all the mountains of Alberta, Montana, Wyoming, and Colorado. Obviously the book is not limited by political boundary constraints.

The book's contributors are a wildlife biologist, Don Blood, formerly with the Canadian Wildlife Service and now in private consulting practice; a wildlife photographer, Tom W. Hall, a specialist in Rocky Mountain photography; and an artist, Susan Im Baumgarten. Their individual talents greatly enhance one another's contributions.

This book is clearly divided into two sections. The first deals with the general geography of the Rocky Mountain region and the behavior and ecology of each major family or group of mammals and birds in the region. Part II, the Natural History Folios, gives a succinct textual summary and an extensive visual representation of each major species of Rocky Mountain mammal. Noticeably absent are references to the species of amphibians and reptiles that frequent the Rocky Mountains.

Of the two parts, the first is much more interesting. Without getting too specific, Blood outlines some of the general features exhibited by animals adapted to living in the mountains. Susan Im Baumgarten's drawings and Tom Hall's photographs nicely illustrate the points made within Don Blood's text.

Whereas in Part I, text, photographs, and drawings all tend to mesh together, in Part II this 'meshing together' is not present. Part II simply lists general features of certain animals and is combined with a collection of photographs. Part II deals only with mammals, unlike Part I which also examines birds. Moreover those treated do not include a complete listing of mammals present in the Rocky Mountains. Had the treatment of Rocky Mountain mammals been complete, then Part II would have been a positive addition to the book; however, since it is not, it should have been omitted.

For persons not familiar with the Rocky Mountains and wishing to know something of life in the mountains, this book will be informative. But the book is neither a field guide nor a complete reference work, and persons seeking either will have to look elsewhere.

PETER CROSKERY

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Wintering Bald Eagle

By Donald A. Spencer. 1976. National Agricultural Chemicals Association, Washington. ix + 170 pp. Free.*

This is a useful compendium of recent anecdotal reports of uneven quality, with an occasional brief attempt at summation and synthesis. It deals with wintering Bald Eagles in the lower 48 states. The state-by-state sequence is repeated for each chapter topic, many of which overlap, including wintering locations, mid-winter inventories, arrival and departure, open water, runs of spawning fish, fish kills, carrion supplement, feeding behavior, communal roosts, and sanctuaries. With no index, this book is difficult to use as a ready reference.

As appropriate, most of the observations have been provided by managers of wildlife refuges. In most cases neither raptor enthusiasts nor regional editors and reporters of *American Birds* were consulted. The older literature has been ignored. Christmas bird counts have been presented for one year only (1974).

A map summarizes the numbers of migrant Bald Eagles in each state, with an estimated total of close to 9000 wintering Bald Eagles, in addition to small resident populations in five areas. Another map shows recovery locations within the United States for four Bald Eagles banded in the Northwest Territories, one banded in Alberta, seven in Saskatchewan, nine in Ontario, and eight in Minnesota.

We learn how wintering Bald Eagles have increased greatly in numbers since construction of control structures on the Mississippi River began in 1930s and on the Missouri in 1953. These eagles feed mainly on waterfowl and crippled ducks, though the eagle can snatch healthy American Coots and even Whistling Swans from the water. Irregular winter kills of fish, such as the Gizzard Shad, supplement this diet. A single roost in Illinois has 180 Bald Eagles on winter nights.

Further west, the introduction of Kokanee Salmon earlier in this century has allowed great concentrations at the spawning sites: e.g., 260 Bald Eagles along 7 miles of McDonald Creek in Glacier National Park in November. In the more open country of the west, away from water, the eagles disperse widely to feed on carrion, including Mule Deer and rabbits killed along highways.

The author, Donald A. Spencer, is a biologist recently retired from the Pesticide Regulation Division of the Agricultural Research Service, and the book is published by the Agricultural Chemicals Association. Nevertheless, only a brief mention speaks of the need for "progressive correction of chemical residue problems in foods eaten by bald eagles."

In spite of its deficiencies, this book is a veritable gold mine of information about wintering Bald Eagles. The publishers have donated one copy each to 3189 university and junior college libraries.

C. STUART HOUSTON

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*Book Review Editor's Note: Limited supplies of this book are available free to persons who write the publishers "explaining your interest in Bald Eagles and the opportunity you may have for observing them in the wild."

Larvae of the North American Caddisfly Genera (Trichoptera)

By G. B. Wiggins; illustrations by A. Odum. 1977. University of Toronto Press, Toronto. 401 pp. $25.

This book represents a major contribution to our knowledge of Trichoptera. Though more than 1200 species have now been described from North America (about one half of these occur in Canada), relatively little attention had been focused on the larvae since Ross' (1944) classical monograph of the Illinois fauna. This was especially unfortunate since the immatures are the ecologically significant stages and those most commonly encountered by field ecologists.

The book is divided into two parts: a short general section outlines the scope and the objectives of the text, summarizes current knowledge on classification, biology and morphology, and indicates techniques for collecting, preserving and studying these insects.

The second section represents the core of the subject. A general key is drawn for the identification of the 18 families recognized (the Arctopsychidae and Goeridae of some authors are included as subfamilies in the Hydropsychidae and the Limnephilidae respectively); its presentation is classic, and the choice of illustrations makes it remarkably clear. Then follow 18 chapters, one on each family, comprising an introductory account of taxonomic and diagnostic, as well as biological and behavioral, information, with a key to the genera. Each genus is then dealt with in alphabetical order. A particularly useful feature is

that two pages are devoted to each genus, the drawings regrouped on the right-hand page, and other information (number of species, distribution, morphological notes, case structure, biology, and key literature) listed on the left-hand page. This renders the book particularly practical in its intended use as a laboratory reference.

The book will be viewed, to some extent as a stepping stone towards a definitive study of the larvae at the specific level, the only one which is truly meaningful in an ecological perspective. A word of caution should be given: there is a danger in ecological generalizations at a generic level, particularly in large genera with many sympatric species in which ecological differentiation must be the prerequisite of coexistence.

Nonetheless this text will remain the standard reference for the study of Trichoptera larvae for many decades to come. Hopefully the author and other taxonomists will complete the task at hand by tackling the taxonomy of species within individual genera, but all these studies will appear as expansions of this basic treatise.

The book will stand as a classic of its kind, for seldom has a taxonomic text allied in such a successful manner scientific expertise, efficient editorial arrangement, and superb draftsmanship. The author and the illustrator are to be congratulated for reminding us that in our age of drab practicality, it is still possible to produce a book that is both essentially practical and aesthetically pleasing.

P. P. HARPER

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BOTANY

A Guide to the Literature on the Herbaceous Vascular Flora of Ontario

By James L. Hodgins. 1977. Available from author, 90 Wolfrey Avenue, Toronto. 25 pp. Paper $2.

Somewhat small to qualify truly for review as a book, its potential value, however, makes it well worth bringing to the attention of naturalists. This booklet will provide an excellent starting point for anyone researching plants in Ontario. It is an inexpensive and easily used reference source for the field naturalist.

The literature covered goes back to the beginning of the century, and extends up to 1977. Representative publications are listed for every county or region of the province. Besides books and maps, an extensive list of journal references and some of the more difficult to find internal publications from various government sources are noted. A list of herbaria in various locations along with approximate numbers of specimens is a useful addition.

The organization of the book, first listing authors under the appropriate counties, districts, or municipalities and then providing the more complete listings by author alphabetical order makes the booklet easy to use. Information on the size or cost and sometimes the source of references is sadly lacking, but this should be considered a minor fault when one considers the inexpensive, up-to-date, and utilitarian nature of this publication. This booklet will provide a useful starting point for my future research in the province.

WILSON EEDY

Beak Consultants Limited, 6870 Goreway Drive, Mississauga, Ontario L4V 1L9

Intermountain Flora, Vascular Plants of the Intermountain West, U.S.A. Volume six, the Monocotyledons

By A. Cronquist, A. H. Holmgren, J. L. Reveal, and P. K. Holmgren. 1977. Columbia University Press, New York. 584 pp., illus. $54.00.

This is the second published volume of the six proposed for the Intermountain Flora. The first, Volume I, which dealt with introductory materials, Pinaceae, Ferns and Fern Allies, was reviewed in *The Canadian Field-Naturalist* 1973, 87: 329–330.

This volume comprises the Orchidaceae (by A. Holmgren), Poaceae (by A. and N. Holmgren), Cyperaceae, Juncaceae and *Allium* (by A. Cronquist), Agavaceae, Alismataceae, Butomaceae, Commelin-

aceae, Hydrocharitaceae, Juncaginaceae, Lemnaceae, Liliaceae (except *Allium*), Najadaceae, Potamogetonaceae, Ruppiaceae, Sparganiaceae, Typhaceae, and Zannichelliaceae (by J. Reveal).

Those who have used the *Vascular Plants of the Pacific Northwest* will recognize the fine line-drawings of Jeanne R. Janish where the species treated are the same as in that flora. New drawings have been done by seven other artists as well as Janish. The fine detail on most of the plates will greatly facilitate identification of specimens.

The format follows that set out in Volume 1, with keys, detailed descriptions, synonomy (with bibliographic references and type specimens), references, habitat, and distributions. Chromosome numbers are also given, but there is no indication of whether these counts were made on specimens from the Intermountain Region.

The following new taxa and transfers are presented: *Potamogeton filiformis* var. **latifolius** (J. W. Robbins) Reveal, *Juncus ensiformis* var. **brunnescens** (Rydb.) Cronq., *Scirpus pungens* var. **longispicatus** (Britton) Cronq., *Carex scirpoidea* var. **curatorum** (Stacey) Cronq., *Aristida purpurea* var. **glauca** (Nees) A. & N. Holmgren, *A. purpurea* var. **robusta** (Merr.) A. & N. Holmgren, *Calochortus panamintensis* (Ownbey) Reveal, *Allium atrorubens* var. **inyonis** (M. E. Jones) Ownbey & Aase, *A. bisceptrum* var. **palmeri** (S. Wats.) (Cronq., *Yucca harrimaniae* var. **neomexicana** (Wooton & Standley) Reveal, *Y. baileyi* var. **intermedia** (McKelvey) Reveal, *Y. elata* var. **utahensis** (McKelvey) Reveal, *Y. elata* var. **verdiensis** (McKelvey) Reveal, *Y. angustissima* var. **kanabensis** (McKelvey) Reveal, *Y. angustissima* var. **toftiae** (S. L. Welsh) Reveal, *Y. angustissima* var. **avia** Reveal, *Sisyrinchium douglasii* var. **inflatum** (Suksd.) P. Holmgren.

This volume is a welcome contribution to the floras of western North America. It will be must useful, not only in the Intermountain Region, but also in the adjacent states, and in the southern parts of Western Canada as well. Range workers will find this volume particularly useful. Because it may frequently be used by itself, it would have been useful to include a map of the Intermountain Region, perhaps on the inside front cover.

WILLIAM J. CODY

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Atlas of the Flora of the Great Plains

By Great Plains Flora Association; R. L. McGregor, Coordinator, T. M. Barkley, Editor. 1977. The Iowa State University Press, Ames. 600 pp. $25.00.

This is a collection of distribution maps of 2217 taxa of vascular plants, which comprise the commoner plants found in the Great Plains of the western United States. An additional list of some 850 taxa that are either rare or of restricted occurrence, together with known localities, is also provided. Thus distributional data for some 3067 taxa of this important region, which lies west of continuous woodland and east of the Rocky Mountain uplift and from the Canadian border south to the Texas panhandle, are now available.

The Great Plains region is outlined on the map, which shows a mosaic of counties within the various states. It includes all of the states of Kansas, Nebraska, South Dakota and North Dakota, the eastern parts of Montana, Wyoming and Colorado, northeast New Mexico, the Texas panhandle, northwest Oklahoma and the western parts of Iowa, Missouri, and Minnesota. In the introduction to the volume, there is a full-page map depicting the county names. It would have been helpful to add the names of the states on this map, particularly for those of us from outside the region to whom the political geography is not familiar.

This collection of distribution maps will be a basis for a proposed flora of the region. This will be most welcome when it is finally published, because the only flora which covers the region is the now outdated *Flora of the Prairies and Plains of Central North America* by P. A. Rydberg (1932). It is also, as the authors claim, an up-to-date checklist of the flora of the region which, with the distributional data provided, can be of considerable value to the ecological planners upon whose advice the sane management of natural resources must rest. To the plant geographer the information provided in this work is a step towards a more comprehensive knowledge of the distributions of plant species. Users should, however, be cautious, in that the distributions shown on the maps for counties and states outside the plains region, may not be complete.

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ENVIRONMENT

Structure and Function of Tundra Ecosystems

Edited by T. Rosswell and O. W. Heal. 1975. Swedish Natural Science Research Council, Stockholm. 450 pp. 50 SKr.

This volume is Number 20 in a series of Ecological Bulletins published by the Swedish Natural Science Research Council and is partly the proceedings from the 5th International Meeting on Biological Productivity of Tundra, held in Abisno, Sweden in 1974.

A series of sixteen papers is presented from sites in the following regions: Arctic tundra (Canada, U.S.A., U.S.S.R.) subarctic and subalpine (Finland, Norway, Sweden, U.K., Greenland), alpine (Austria), maritime and subarctic tundra. These sites were components of the Tundra Biome of the International Biological Programme (I.B.P.). Each paper presents the results of detailed and intensive research conducted at the sites.

The research provided site-specific information on species composition, population density, production, and activity of the flora, fauna, and microflora. Each paper develops a "word model" which discusses the functional characteristics of the ecosystem and its components. The word model is seen as the forerunner of mathematical models which are to explore the dynamics of the ecosystems and are designed to allow inter-site comparison. Only one such simulation model is presented in the volume.

The word models differ considerably in approach, reflecting the differences in site ecology, levels of human activity, completeness of research, and attitudes of the authors.

In recent times, tundra areas and arctic regions have risen in importance to industrial societies. On the other hand, native populations, which have been an integral part of tundra ecosystems, are changing their lifestyles and land-use patterns rapidly. Tourism is also a relatively new factor in the Arctic and will presumably exert an impact on ecosystems and traditional lifestyles.

The volume is well illustrated with scores of tables, charts, and graphs presenting various data from each site. Very comprehensive reference lists are detailed for each paper and these are an invaluable tool for the researcher.

This book is not for casual consumption but does represent a very useful source of data for the serious arctic researcher or the advanced student ecologist wishing to peruse methods and results of research on tundra ecosystems.

DAN MURPHY

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Canada's Threatened Species and Habitats

Edited by Theodore Mosquin and Cecile Suchal. 1977. Proceedings of the First National Conference on Canada's Threatened Species and Habitats, Ottawa, May 1976. Canadian Nature Federation, Ottawa. x + 185 pp. $8.00.

This publication evolved from a symposium co-sponsored by the Canadian Nature Federation and the World Wildlife Fund (Canada). The objective of the symposium . . . "was to look at facts, exchange ideas, examine some successful management programs, review government policies and make proposals for corrective action." In my opinion, the conference achieved these goals, which are documented in 38 papers and a list of recommendations and resolutions approved at the symposium.

The papers are organized into eight sections: The Problems in a National Context; Large Land Mammals; The Marine World; Birds; Amphibians and Reptiles; Plants, Insects, Molluscs and Fresh Water Fishes; The Protection of Natural Habitats; The Future: Problems and Solutions. Two of the papers presented have been omitted from the text. The paper by D. E. Sergeant, "Marine Mammals in Relation to Pressures on the Oceans' Food Chain," is not available for publication and has been replaced with an abridged summary. The second paper, "The Peregrine Falcon: Population Declines and Captive Breeding Experiments" by Richard Fyfe, is not included because it has appeared in *Nature Canada,* Volume 5(2), 1976, and *The Canadian Field-Naturalist,* Volume 90(3), 1976.

In the first section, Michael Singleton, in his paper "Endangered Species Legislation in Canada," does a nice job of summarizing this complicated and often confusing subject. He describes present legislation as . . . "piecemeal, jumbled and cosmetic," and feels that . . . "Canada is well behind other countries we refer to as

underdeveloped, both in legislation and in programs." He concludes with the following thought: "We have the potential to move forward quickly. If the domain and the provincial governments can grow up enough to stop the petty jurisdictional squabbling, assign themselves duties as well as powers, and assign monies in keeping with the priority of endangered species, then we will see results."

In the following five sections many of the papers concentrate on species which have been extensively studied, species which, although not new to the rare and endangered lists, are examples with sufficient evidence to confirm their precarious state in nature.

Ian Stirling reviews the status of the Polar Bear and A. M. Pearson the Grizzly Bear, while Douglas Pimlott, a foremost authority on the Canidae, and J. B. Theberge focus on wolves. The present status and future prospects of Canada's Mountain Sheep are described by R. Demarchi, and David Gray writes of the Muskox and the Caribou on Canada's arctic islands. The status of seals in Canada is reviewed by Ian McLaren.

Without doubt, the most impressive paper in this volume is "Environmental Contaminants and the Future of Fish-Eating Birds in Canada," by Kees Vermeer and David Peakall. The authors have gathered data pertaining to the effects of DDE, PCB, and mercury residues in fish-eating birds, birds that occupy the highest trophic levels in the ecosystem and which . . . "can be used as pollution indicators of the aquatic environment." Also included in this section are papers on the Whooping Crane, North American waterfowl, Eastern Canada seabirds, and an analysis by Clive Goodwin of "Rare and Threatened Birds of Canada."

George R. Francis sums up the Canadian herpetological scene with two points: . . . "first, remarkably little is known about Canada's herpetofauna; second, not enough is done with what is known to meet conservation needs." Both aspects of this theme are verified in the five accompanying papers of this section, which review the status of frogs, toads, snakes, lizards, and turtles in Canada.

G. W. Argus presents the only paper on rare and endangered flora in Canada, and D. E. McAllister and C. G. Gruchy review the status of Canadian fishes. The latter paper comes complete with an annotated list of extinct, threatened, and endangered species of fishes in Canada. Insects are reviewed by E. Munroe and molluscs by A. H. Clarke.

The final eight papers concentrate on parks, ecological reserves, and the future. In "Meeting the Needs of the Future: A Provincial Perspective on Threatened Species and Habitats," James Hatter brings it all into perspective by stating that . . . "needs for the future can only be met with close co-operation and support by all members of the public to ensure that critical environments are protected."

Most of the papers, short and broad in scope, are written and designed for a general audience. Half are well documented with reference lists and many more are illustrated with graphs, tables, and photographs.

I recommend this book to students of environmental biology.

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OTHER

Photography for the Joy of It

By Freeman Patterson. 1977. Van Nostrand Reinhold, Toronto. 168 pp., illus. Cloth $19.95; paper $9.95.

Many naturalists are photographers, but each has his own individualistic approach to appreciating the beauty of nature. Patterson is an expert at both. The philosophy, demonstrated throughout his writings and photography, emphasizes how to insert your own interpretation and feeling into a photograph, a permanent record of a passing moment of joy. Patterson teaches in a practiced yet entertaining manner. I could not help rushing out to try some of the many hints and suggestions offered in every chapter.

This book is highly recommended for all who wish to record the feelings of joy observed in the world around us. It is one of the most fascinating books I can remember. Not only did I enjoy the author's style of writing, but words cannot really describe the photography. The artistic beauty of these photographs alone makes the book more than worthwhile. One small fault, however, was the frequent placement of examples depicting a certain technique far from the section of the text in which it was discussed.

Patterson's photographs mostly reflect his own experience and love for the Canadian environment. Examples range from Mule Deer in the Rockies to coastal dunes and intertidal riches, from a stairway in the east block of parliament to the joyous face of a young Inuit, from a winter moonlit night over Longlac to the mystery of the changing seasons in his own back yard. The 50 hints at the end provide an excellent and extremely useful summary.

For those who are not yet convinced, some samples from this book may be previewed in the 25 February 1978 Weekend Magazine. If this feature impresses you even slightly, you can magnify the impression many times in approaching the magnificence of color, depth of field, and sharp contrast demonstrated in the book version. Compliments should be extended to the publishers for executing a suitable reproduction of Patterson's abilities.

WILSON EEDY

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NEW TITLES

Zoology

Animals and man. Their relationship as reflected in western art from prehistory to present day. 1977. By K. Clark. Morrow, New York. 240 pp., illus. US $19.95.

Annotated bibliography of bird kills at man-made obstacles: a review of the state of the art and solutions. 1977. By R. D. Weir. Fisheries and Environment Canada, Ottawa. 85 pp. Free.

†**An annotated bibliography of the muskellunge, *Esox masquinongy (Osteichthyes: Salmoniformes*).** 1978. By E. J. Crossman and Cheryl D. Goodchild. Life Sciences Miscellaneous Publications. Royal Ontario Museum, Toronto. 131 pp. Paper $4.50.

Assessing the effects of power-plant-induced mortality on fish populations. 1977. Edited by W. van Winkle. Proceedings of a conference 3–6 May 1977, Gatlinburg, Tennessee. Pergamon, New York. 380 pp., illus. US $22.50.

The Audubon Society book of wild animals. 1977. By Les Line and Edward Ricciuti. Abrams, New York. 296 pp., illus. US $37.50.

A bibliography of eiders. 1977. By H. Milne and C. P. Dau. Faune du Québec Bulletin 20. Ministère du Tourisme, de la Chasse et de la Pêche, Québec. 225 pp. + 23 addendum. Free.

Biology of bats, volume 3. 1971. Edited by R. M. Wollasalt. Academic, New York. 651 pp., illus. US $59.

Biology of bryozoans. 1971. Edited by R. M. Woollacott and R. L. Zimmer. Academic, New York. 566 pp., illus. US $35.

***Birds and marine mammals.** The Beaufort Sea and the search for oil. 1977. By Donald A. Blood. Edited by Brian D. Smiley. Line drawings by J. Morgan. The Beaufort Sea Project. Available through the Department of Fisheries and Environment, Sidney, British Columbia. 124 pp., illus. Paper $2.50.

Brachiopods from the Caribbean Sea and adjacent waters. 1977. By G. Arthur Cooper. Studies in Tropical Oceanography, No. 4. University of Miami Press, Coral Gables, Florida. xii + 212 pp., illus. US $29.95.

British butterflies. A field guide. 1978. By Robert Goodden. David and Charles (Canadian distributor Douglas, David and Charles, Vancouver). 126 pp., illus. £4.50.

The biology of cephalopods. 1977. Edited by M. Nixon and J. B. Messenger. Proceedings of a symposium, London, April, 1975. Academic, New York. xviii + 616 pp., illus. US $41.

Brother whale: a pacific whalewatcher's log. 1977. By Roy Nickerson. Chronicle, San Francisco. 155 pp., illus. Paper US $4.95.

Carabid beetles in their environments. A study on habitat selection by adaptations in physiology and behavior. 1977. By H.-U. Thiele. Zoophysiology and Ecology, Volume 10. Springer-Verlag, New York. 380 pp., illus. US $44.20.

Caribbean reef invertebrates. 1977. By Patrick Colin. TFH (Canadian distributor Clarke Irwin, Toronto). $21.95.

Characoids of the world. 1978. By J. Gerry. TFH (Canadian distributor Clarke Irwin, Toronto). 650 pp., illus. $25.50.

Columbia River salmon and steelhead. 1977. Edited by E. Schwiebert. Proceedings of a symposium, Vancouver, Washington, March, 1976. American Fisheries Society, Bethesda. 214 pp., illus. Paper US $10.

The coyote: defiant songdog of the west. 1977. By Francois Leydet. Chronicle, San Francisco. 222 pp., illus. US $7.95.

†**The dragonflies of British Columbia.** 1977. By Robert A. Cannings and Kathleen M. Stuart. Handbook No. 35. British Columbia Provincial Museum, Victoria. 254 pp., illus. $2.

Environmental physiology of animals. 1977. Edited by J. Bligh, J. L. Cloudsley-Thompson, and A. G. MacDonald. Halsted/Wiley, New York. viii + 456 pp., illus. Cloth US $42.50; paper US $19.95.

The first ten years of the co-operative breeding bird survey in Canada. 1978. By Anthony J. Erskine. Canadian Wildlife Service Report Series No. 42. Supply and Services Canada, Ottawa. 59 pp., illus. Paper $3.75 in Canada; $4.50 elsewhere.

†**A guide to the birds of Venezuela.** 1978. By R. M. de Schauensee and W. H. Phelps, Jr. Princeton University Press, Princeton. xix + 424 pp., illus. Cloth US $50; paper US $19.95.

†**The great arc of the wild sheep.** 1978. By James L. Clark. 4th printing (1st edition 1964). University of Oklahoma Press (Canadian distributor Burns and MacEachern, Toronto). 247 pp., illus. Paper $11.50.

How wildlife survives natural disasters. 1977. By Sarah R. Riedman. McKay, New York. vi + 154 pp., illus. US $7.95.

Insects are animals too. 1978. By Anthony Wooton. David and Charles (Canadian distributor Douglas, David and Charles, Vancouver). 136 pp., illus. Approximately £3.95.

Life on a little-known planet. 1978. By H. E. Evans. Dutton (Canadian distributor Clarke Irwin, Toronto). 320 pp., illus. Paper $6.25.

*__Little mammals of the pacific northwest.__ 1977. By Ellen B. Krilzman. Pacific Search, Seattle. 118 pp., illus. Paper US $5.95.

†**Nichoirs d'oiseaux.** 1978. Par Raymond Cayouette. Illustrations de Jean-Luc Grondin. La Société zoologique de Québec, Charlesbourg. 36 pp., illus. Paper $4.

Physiology and behaviour of marine organisms. 1978. Edited by D. S. McLusky and A. J. Berry. Proceedings of the 12th European Symposium on Marine Biology. Pergamon, New York. 404 pp. US $40.

Primate conservation. 1977. Edited by H. S. H. Prince Ranier III and G. H. Bourne. Academic, New York. 658 pp., illus. US $39.50.

†**Soil organisms as components of ecosystems.** 1977. Edited by U. Lohm and T. Persson. Proceedings 4th International Soil Zoology Colloquium, Uppsala, June, 1976. Ecological Bulletins Volume 25. NFR, Stockholm, 614 pp., illus. Paper 140 SwCr.

†**Statistical inference from band recovery data — a handbook.** 1978. By C. Brownie, D. R. Anderson, K. P. Burnham, and D. S. Robson. Fish and Wildlife Service Resource Publication No. 131. U.S. Department of the Interior, Washington. 212 pp. Paper free.

†**Tertiary mammals of Saskatchewan, part IV: the Oligocene Anthracotheres.** 1978. By Loris S. Russell. Life Sciences Contributions No. 115. Royal Ontario Museum, Toronto. 16 pp., illus. Paper $1.25.

Transactions 2nd North American Wild Sheep Conference, Denver, 22–23 April, 1976. 1977. Edited by E. Decker. Department of Fishery and Wildlife Biology, Colorado State University, Ft. Collins. 97 pp. US $4.

†**The trilobites *Bathyurus* and *Eomonorachus* from the middle Ordovician of Oklahoma and their biofacies significance.** 1978. By Rolf Ludvigsen. Life Sciences Contributions No. 114. Royal Ontario Museum, Toronto. 18 pp., illus. $1.25.

†**Wild geese.** 1978. By M. A. Ogilvie. Buteo, Vermillion, South Dakota. 350 pp., illus. US $25.

*__Working for wildlife.__ The beginning of preservation in Canada. 1978. By Janet Foster. University of Toronto Press, Toronto. 296 pp., illus. $19.95.

BOTANY

*__Atlas of airborne pollen grains and spores of northern Europe.__ 1977. Natur och Kultur. Stockholm. 159 pp., illus. no price given.

The best plant book ever. The comprehensive gift to living with plants. 1977. By G. Sedon. Rand McNally, New York. 208 pp., illus. Cloth US $12.50; paper US $7.95.

Botanical prints with excerpts from the artist's notebooks. 1977. By Henry Evans. Freeman, San Francisco. 66 pp. US $25.

*__*Carex* in Saskatchewan.__ 1977. By John H. Hudson. Bison, Saskatoon. 192 pp. $10 + 50¢ handling.

Eastern North America's wildflowers: a full-colour guide: 373 life-sized paintings for easy flower identification. 1977. By Louis C. Linn. Dutton (Canadian distributor Clarke Irwin, Toronto). 256 pp., illus. $9.95.

†**Flora of Alberta — a checklist.** 1977. Compiled by D. F. Brunton. Alberta Department of Recreation, Parks and Wildlife, Edmonton. 43 pp. Free?

The flowers of the mediterranean. 1978. By Oleg Polunin and Anthony Huxley. Chalto and Windus (Canadian distributor Clarke Irwin, Toronto). 272 pp. Paper $10.95.

Marine algae of California. 1976. By Isabelle A. Abbott and George J. Hollenberg. Stanford University Press, Stanford. xvi + 827 pp., illus. US $22.50.

*__A provisional checklist of species for flora North America.__ 1978. Edited by Stanwy G. Shelter and Lawrence E. Skog. Revised edition. Monographs in Systematic Botany, Volume 1. Missouri Botanical Garden, St. Louis. xix + 199 pp. Paper US $6.50.

ENVIRONMENT

Biogéographie et evolution en Amérique tropicale. 1977. Edited by Descimon. Papers from a colloquium, Paris. May, 1976. Publications No. 9 Laboratoire de zoologies de l'Ecole normale supérieure, Paris. viii + 344 pp., illus. Paper 80F.

Biological implications of metals in the environment. 1977. Edited by H. Drucker and R. E. Wildung. Energy Research and Development Symposium Series No. 42. Proceedings of a Symposium 29 September to 10 October, 1975, Richland, Washington. National Technical Information Service, Springfield, Virginia. 682 pp., illus. Paper US $10.50 (+ foreign handling charges in Canada).

Biological solar energy conversion. 1977. Edited by A. Mitsui, S. Miyachi, A. San Pietro and S. Tamura. Proceedings of a conference, University of Miami, November, 1976. Academic, New York. 465 pp. US $18.50.

†**Canadian conservation directory 1978–1979.** 1978. Edited by Bette Pratt. 3rd edition. Canadian Nature Federation, Ottawa. 96 pp. Paper $2 + 50¢ handling.

Coastal upwelling ecosystems analysis program — JOINT I. 1977. Edited by Francis A. Richards. Also published as Deep-Sea Research 24(1). Pergamon, New York. 128 pp., illus. US $15.

The coastline. A contribution to our understanding of its ecology and physiography in relation to land-use and management and the pressures to which it is subject. 1977. Edited by R. S. K. Barnes. Wiley-Interscience, New York. xii + 356 pp., illus. US $28.50.

Ecological (biophysical) land classification in Canada. 1977. Edited by J. Thie and G. Ironside. Ecological Land Classification Series. Proceedings of a workshop, Petawawa, Ontario, May, 1976. Fisheries and Environment Canada, Ottawa. 269 pp., illus. Free.

Ecological (biophysical) land classification in urban areas. 1977. Edited by E. Wiken and G. Ironside. Proceedings of a workshop, Toronto, November, 1976. Fisheries and Environment Canada, Ottawa. 167 pp., illus. Paper $4 in Canada; $4.80 elsewhere.

Economics of natural and environmental resources. 1977. Edited by Vernon L. Smith. Gordon and Beach, London, England. 512 pp. $24.50.

Ecoregions of the Yukon Territory. 1977. By E. T. Oswald and J. P. Senyk. Report BC — X — 164. Fisheries and Environment Canada, Ottawa. 115 pp., illus. Paper free.

The end of natural history: the disappearance of the magic and miraculous from science. 1978. By Wolf Lepenies. Translated by Jean Steinberg. Urizen (Canadian distributor Clarke Irwin, Toronto). 225 pp. $16.50.

Environmental education. Key issues of the future. 1977. Edited by D. Hughes-Evans. Published as a supplement to the journal *Habitat*. Pergamon, New York. 92 pp., illus. US $9.

†**The environmental impact of outdoor recreation.** 1977. By Geoffrey Wall and Cynthia Wright. Department of Geography Publication Series No. 11. University of Waterloo, Waterloo. x + 69 pp., illus. Paper $5.

Environmental studies — James Bay and surrounding area, 1975–76. 1977. By anonymous. Environmental Assessment Studies. Fisheries and Environment Canada, Ottawa. 151 pp., illus. Free.

Environment III. Environmental problem solving. 1978. Proceedings of a conference, September, 1977, Vancouver. Association of Consulting Engineers of Canada, Ottawa. 443 pp., illus. Paper $50.

Fate and effects of petroleum hydrocarbons in marine organisms and ecosystems. 1977. Edited by D. A. Wolfe. Proceedings of a symposium, Seattle, November, 1976. Pergamon, New York. 165 pp., illus. US $44.

Geology in the urban environment. 1978 (due November). Edited by R. O. Utgard, G. D. McKenzie, and D. Foley. Burgess, Minneapolis. 352 pp. Price to be announced.

Man, land, and the forest environment. 1977. By Marion Clawson. The George S. Long Publication Series. University of Washington Press, Seattle. xii + 74 pp., illus. US $6.95.

Pacific seashores: a guide to intertidal ecology. 1978. By T. Carefoot. University of Washington Press, Seattle. 208 pp. US $12.95.

Reconnaissance of the soils and vegetation of Somerset and Prince of Wales Islands, NWT. 1977. By V. Woo and S. C. Zoltai. Information Report NOR-X-186. Fisheries and Environment Canada, Ottawa. 127 pp. Free.

Science for better environment. 1977. Edited by Y. Fukushima. Environmental Sciences and Applications, Volume 2. Pergamon, New York. 1000 pp. US $82.50.

True Lowland, Devon Island, Canada: a high arctic ecosystem. 1977. Edited by L. C. Bliss. University of Alberta Press, Edmonton. 714 pp., illus. $20.

The unfinished agenda: the citizen's policy guide to environmental issues. 1977. Edited by G. O. Barney. Crowell, New York. viii + 184 pp. Cloth US $7.95; paper US $3.95.

Wilderness is all around us: notes of an urban naturalist. 1978. By Eugene Kinkead. Dutton (Canadian distributor Clarke Irwin, Toronto). 224 pp., illus. $12.50.

MISCELLANEOUS

†**Annotated list of workers on systematics of Canadian insects and certain related groups.** 1977. By the secretariat. Entomological Society of Canada, Ottawa. 107 pp. Paper free.

Applications of climatology. 1977. Edited by J. M. Powell. Proceedings of a workshop. Report NOR-X-193. Fisheries and Environment Canada, Ottawa. 137 pp. Free.

The exploration of northern Canada, 500 to 1920 a chronology. 1978. By Alan Cooke and Clive Holland. Arctic History Press, Toronto. 544 pp., illus. $60 (limited edition).

Land use programs in Canada: Ontario. 1977. By E. N. Ward. Fisheries and Environment Canada, Ottawa. 198 pp. Paper $1.25 in Canada; $1.50 elsewhere.

*__My life among the Eskimos.__ The Baffinland journals of Bernard Adolph Hantzsch, 1909–1911. 1977. Translated and edited by L. H. Neatby. Institute for Northern Studies, University of Saskatchewan, Saskatoon. xxii + 395 pp., illus. + map. $20.

Polar oceans. 1978. Edited by M. J. Dunbar. Proceedings of the Polar Oceans Conference, McGill University, May, 1974. Arctic Institute of North America, Calgary. x + 682 pp., illus. $40 ($34 to members) + $2 handling if not prepaid.

Rural land use changes in the Ottawa-Hull urban region. 1976. By D. M. Gierman. Occasional Paper No. 9, Fisheries and Environment Canada, Ottawa. 85 pp. + 15 maps. Free.

The sea: ideas and observations on progress in the study of the seas. Volume 6, marine modeling. 1977. Edited by E. D. Goldberg, I. N. McCave, J. J. O'Brien, and J. H. Steele. Wiley, New York. 1048 pp., illus. US $49.50.

Sun: mankind's future source of energy. 1978. Edited by F. DeWinter. Proceedings of a congress, New Delhi, January, 1978. Pergamon, New York. 3 Volumes. US $200.

Sun power: an introduction to the applications of solar energy. 1977. By J. C. McVeigh. Pergamon, New York. 180 pp. Cloth US $16.50; paper US $7.50.

Workshop on economic and legal mechanisms. 1977. International Joint Commission, Windsor. Free.

*assigned for review
†book received and available for review

Correction

In Review of *Ontario Weeds,* Canadian Field-Naturalist 92(1): 102, 1978, correct price is $2.50.

Instructions to Contributors

Content

The Canadian Field-Naturalist is a medium for publication of original scientific research papers in all fields of natural history that have relevance to Canada. As the journal has a flexible publication policy, items not covered in the traditional sections (Articles, Notes, Letters, News and Comment, and Book Reviews) can be given a special place provided they are judged suitable. Naturalists are also encouraged to support local natural history publications.

Manuscripts

Please submit, in either English or French, three **complete** manuscripts written in the journal style. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants, or minerals.

Type the manuscript on standard-size paper, if possible use paper with numbered lines, double-space throughout, leave generous margins to allow for copy marking, and number each page. For Articles, provide a running head, a bibliographic strip, an abstract, and a list of key words. These items are optional for Notes. Generally words should not be abbreviated but use SI symbols for units of measure. Underline only words meant to appear in italics. The names of authors of scientific names should be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. Authors are encouraged to use "proper" common names (with initial letters capitalized) as long as each species is identified by its scientific name once.

Although we prefer the names of journals in the Literature Cited to be written out in full, these may be abbreviated following the **Bibliographic Guide For Editors & Authors**, The American Chemical Society, Washington, D.C. (1974). Unpublished reports should not be cited here. Next list the captions for figures (numbered in arabic numerals and typed together on a separate page) and present the tables (each titled, numbered consecutively in arabic numerals, and placed on a separate page). Mark in the margin of the text the places for the figures and tables.

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Cover: Peary Caribou on Prince of Wales Island, Northwest Territories. Photographed by Anne Gunn in June 1977. See article on page 327.

The Canadian Field-Naturalist

Volume 92, Number 4 October-December 1978

Identification of *Crataegus* Species Native to Manitoba[1]

H. H. MARSHALL

Research Station, Agriculture Canada, Morden, Manitoba R0G 1J0

Marshall, H. H. 1977. Identification of *Crataegus* species native to Manitoba. Canadian Field-Naturalist 92(4): 321–326.

Crataegus, or hawthorn, found in Manitoba seem to be at least 95% *C. rotundifolia*; a small percentage of *C. succulenta* var. *occidentalis* occurs in the southern part of the province. *Crataegus douglasii* and *C. punctata* were probably listed in error and should be excluded. Reasons for confusing *C. rotundifolia* and *C. succulenta* include a smooth membrane covering the deep pits of the nutlet in *C. succulenta*, the failure to use other distinguishing characteristics, considerable variability in *C. rotundifolia*, and inappropriately descriptive scientific and common names for both series and both species.

Key Words: *Crataegus*, Manitoba, identification, taxonomy, distribution.

Four *Crataegus*, or hawthorn, species have been listed as native in Manitoba. Scoggan (1957) listed *C. chrysocarpa* of series *Rotundifolia* (Fireberry Hawthorn) and *C. succulenta* var. *occidentalis* of series *Macracanthae* (Fleshy Hawthorn) as the only common species. He excluded *C. douglasii* (Douglas Hawthorn) which had been listed previously for lack of specimens, but included *C. punctata* (Dotted Hawthorn) on the basis of one collection by Macoun in 1872. In a more recent flora, Boivin (1967) excluded *C. punctata* because of errors in dating and identification and listed *C. chrysocarpa* under *C. rotundifolia*. In North Dakota, Stevens (1963) lists only *C. rotundifolia* for the northern part of the state, which is only 16 km from Morden, Manitoba at the closest point.

The number of hawthorn species in Manitoba is smaller than is usual in any comparably sized area in temperate North America (Fernald 1950), so there would seem little reason for confusion. Scoggan (1957), however, stated that further study is needed for the Manitoba species. This statement is supported by listings of different numbers of species for Manitoba and adjacent North Dakota (Stevens 1963), and by the author's observation that herbarium and arboretum specimens of native hawthorn are not identified fully or consistently. Although the author's long observations of native flora in southern Manitoba have shown that two groups of hawthorn usually can be distinguished, a critical study of specimens from native stands was conducted to clarify several potentially useful diagnostic characters.

Specimens of hawthorn in flower were collected on 1 and 7 June 1971 along the Pembina Hills SW to NW of Morden, Manitoba. The location was recorded in detail for each collection and any unusual circumstances were noted. Specimens were collected from a small section of a stand or from isolated plants. The plants were marked with spray paint to ensure that later collections of fruit could be made from the same plants. Mature fruit was collected on 2 or 14 September 1971. Specimens were pressed, dried, mounted, and stored at the Research Station, Morden. A few leaves of each fruiting specimen were coated on the underside, while fresh, with Archer's solution to preserve a print of the stomata.

[1]Research Station Contribution Number J-160.

When specimens were collected the date of peak bloom for each plant was estimated, and observations were made on the general habit of the plant. Measurements were made on thorns, leaves (length, width, location of widest point, size of stomata, number of veins and teeth and their prominence, glands on teeth), flowers (width, glands on sepals, pubescence, anther color), and fruit (general size, color, number of seeds, and size and form of seeds).

Results

The data on the specimens (Table 1) show that in general they are referable to the two main species listed by Scoggan (1957). The 19 collected 1 June seem to agree with descriptions of *C. chrysocarpa* while the 10 collected 7 June are close to *C. succulenta* var. *occidentalis*. For simplicity these two binomials without the variety name will be used in the remainder of this paper. The nomenclature of *C. chrysocarpa* or *C. rotundifolia* will be considered under Discussion. Common names will not be used because all species are called hawthorn with no attempt to distinguish between them.

Several items which were observed are not presented, either because no differences were found or because they were not easily measured. The size of the plant and length of thorns varied widely and hence were of limited value for recognition. Pubescence varied considerably among specimens with the least on some *C. chrysocarpa* and most on *C. succulenta*, but several specimens in the first group were intermediate. Seed counts per fruit were attempted but were considered unreliable because certain plants had few fruits and insects damaged most specimens. Described differences in seed number in these species are small (Scoggan 1957).

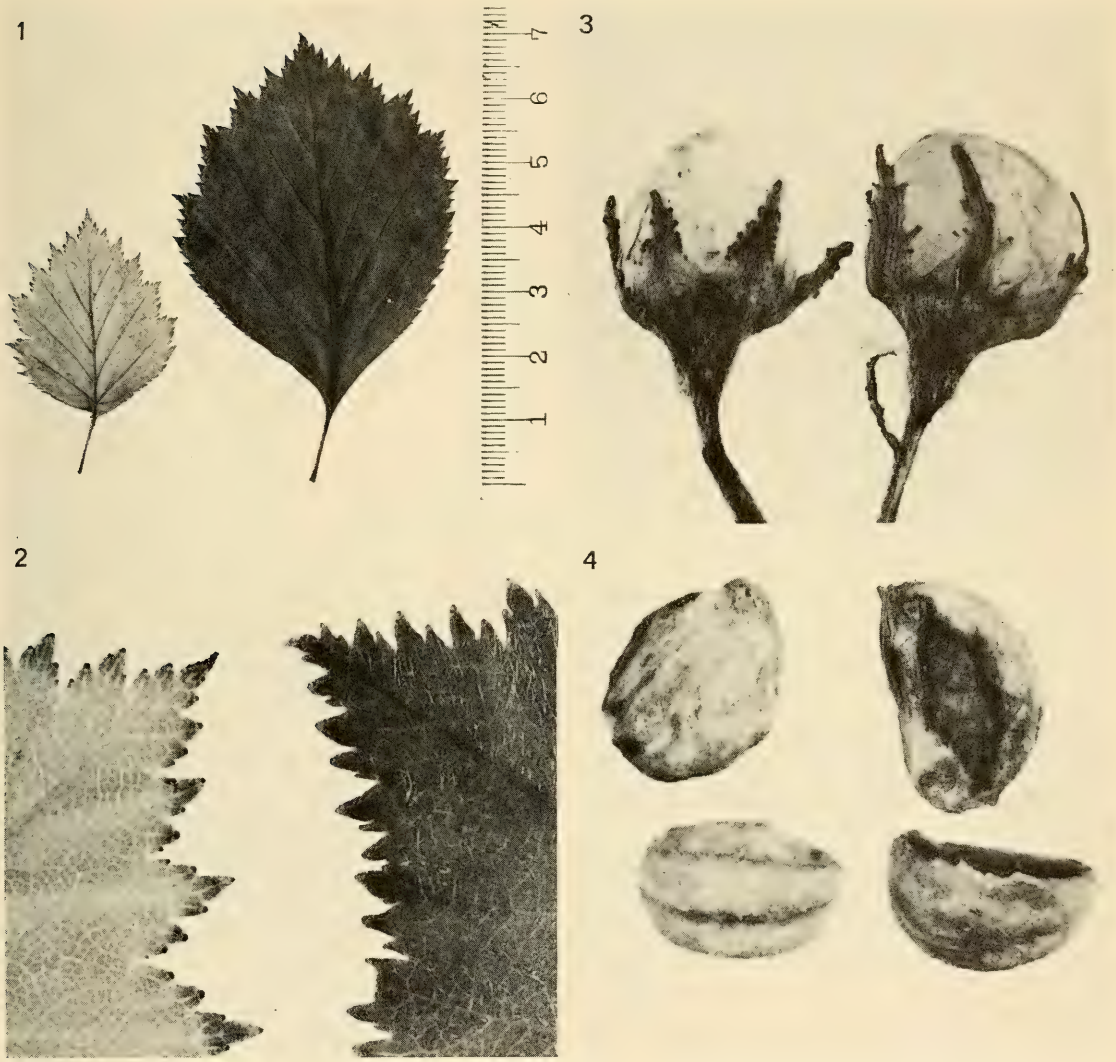
Date of bloom seemed to vary consistently between the two species. Differences in other characters were noticeable at blossom time; for example the leaves were about one-third expanded in *C. chrysocarpa* and two-thirds in *C. succulenta* (Figures 1, 2). At this stage there was also an apparent difference in thickness or density of the leaves, with the latter species exhibiting thicker leaves. Part of this probably was because of the more advanced maturity of *C. succulenta*; however, this difference also appeared in the thicker, more leathery leaves of fruiting specimens.

Leaves differed in the number and size of compound teeth or lobes, in the position of the widest point of the leaf, in the form of glands on the teeth, and in stomata size. *Crataegus succulenta* leaves were widest below the midpoint of the leaf and commonly had two large compound teeth below this point (Figures 1, 5). *Crataegus chrysocarpa* leaves were widest above the middle of the leaf, had no teeth on the cuneate base, small simple teeth on the lower half, and small-to-medium-size compound teeth on the upper half. When the leaf length above the widest point was plotted against the length below the widest point the data formed two groups with a few exceptions (Figure 5). The smallest specimen of *C. succulenta* was from a weak plant that has died. The position of the

TABLE 1—Means and range (in parentheses) for characteristics of hawthorn specimens collected near Morden, Manitoba

Characteristic	*Crataegus chrysocarpa*	*Crataegus succulenta*
Veins per leaf, number	8.7 (7–11)	10.3 (9–13)
Size of lobes, rating*	4.6 (4–5)	2.0
Leaf glands, rating*	2.9 (2–4)	1.0
Leaf length, mm	46.0 (32–67)	52.4 (39–61)
Leaf width, mm	37.9 (26–51)	39.4 (31–46)
Leaf base to widest point, mm	21.1 (13–30)	30.3 (21–35)
Leaf proportion, $\frac{\text{length above widest point}}{\text{length below widest point}}$	1.21 (0.78–1.92)	0.74 (0.63–0.86)
Stomata length, μm	37.2 (35.0–39.4)	31.5 (30.4–33.0)
Full bloom, date 1971	1.2 (1–5 June)	6.1 (5–7 June)
Seed length, mm	6.4 (6.0–7.0)	6.0 (5.5–6.5)
Seed pits on inner face, rating*	1.6 (1–4)	4.4 (4–5)
Seed, outer ridges, rating*	3.7 (2–4)	2.7 (2–3)

*Ratings from 1 (small or inconspicuous) to 5 (large or conspicuous).



FIGURES 1–4. *Crataegus chrysocarpa* (left) and *C. succulenta* (right). 1, Leaves showing differences in size in anthesis, in leaf density due to thickness, and size and position of teeth. 2, Glands on leaf teeth are more conspicuous on *C. chrysocarpa*. 3, Glands on sepals (and on caducous stipules) are distinct and sessile on *C. chrysocarpa* and less distinct on longer teeth of *C. succulenta*. 4, Nutlets showing roughened inner face on *C. chrysocarpa* and dark pit which may be covered with a smooth membrane in *C. succulenta*.

widest point is represented diagramatically based on the means of all specimens on the right side of Figure 5.

The leaves of *C. chrysocarpa* bore distinct dark glands on the tips of the teeth (Figure 2) while the leaves of *C. succulenta* bore indistinct green glands. Similar glands were found on the stipules, which fall quickly in these species, and on the sepals (Figure 3). Glands on both stipules and sepals were dark and sessile in *C. chrysocarpa* and greenish and borne on stalk-like teeth in *C. succulenta*. An analysis of variance showed stomata length did not differ significantly (P =0.05) within either species, but the difference between *C. succulenta* (mean, 31.5 μm) and *C. chrysocarpa* (mean, 37.2 μm) was highly significant (P = 0.01).

Flowers of the two species differed in time of

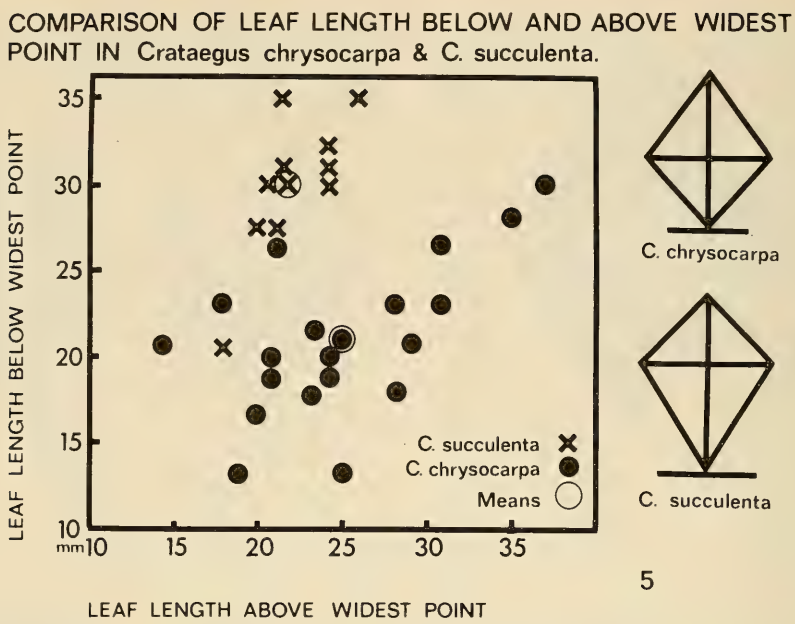


FIGURE 5. Comparison of leaf form in *C. chrysocarpa* and *C. succulenta*. In *C. chrysocarpa* the widest point of the leaves was usually below the mid-point of the length and in *C. succulenta* it was above, as shown in diagrammatic representation of the mean length, width, and position of widest point in both species.

anthesis; sepals in form of serrations and color and apparent size of glands; and fruits in time of maturity, texture, nutlet size, and form of both the inner and outer sides of the nutlets (Figure 4). *Crataegus succulenta* specimens were more uniform than those of *C. chrysocarpa* and several specimens of the latter resembled the other species in one or more characters (Table 1).

Discussion

Studies of native hawthorn in Southern Manitoba support the recognition of two taxonomic groupings. The report of dark-fruited *C. douglasii* by Macoun appears to have been questioned correctly by Scoggan (1957). In 40 years of studying plants in much of southwestern Manitoba, I have seen no *Crataegus* with black or purple fruits except in cultivation. Rehder (1949) points out that *C. macracantha*, a species similar to *C. succulenta*, had been misidentified as *C. douglasii* by Macoun in 1883. This would seem a probable origin for listing *C. douglasii* in Manitoba.

A second species, *C. punctata* collected by John Macoun in 1872 also has been cited wrongly for Manitoba. Berton's (1970) account of this journey indicates there was insufficient time for a trip to Point du Chien (Doghead Point, Lake Winnipeg); therefore the exact area listed by Macoun is unknown. Also, Boivin (1967) logically views the data 14 August 1872 as inconsistent for a flowering specimen and, further, that the correct identification of the specimen is *C. succulenta*.

The data show that two groups corresponding well with Fernald's (1950) descriptions of *C. chrysocarpa* and *C. succulenta* var. *occidentalis* have been collected. Why then should there be so much confusion about *Crataegus* in Manitoba? There seem to be several reasons. The fact that in both species neither the series nor the specific names are particularly appropriate contributes in a major way. Series *Rotundifolia* have leaves of about the same length and width but their deeply toothed form does not suggest roundness. Large thorns are a feature of *Macracanthae* but also of other *Crataegus* series. *Crataegus chrysocarpa* usually does not have golden fruit nor are those of *C. succulenta* particularly fleshy or juicy. Similarly the common name Fireberry Hawthorn is not distinctive because mature fruits of both species are bright red. Fleshy

Hawthorn is a translation of the specific name and is no more appropriate.

Botanical keys stress the deeply pitted inner face of *C. succulenta* nutlets but do not indicate that these are covered frequently by a smooth membrane while the plain inner face of *C. chrysocarpa* is roughened and somewhat pitted in certain specimens. Insects, common in these fruits, attack the inner face of nutlets, adding their pits and scars. Differences are, in general, as indicated in botanical keys but other factors can obscure the true status of nutlet pits. The possibility of mismatched specimens of flowers and fruit cannot be ignored when specimens must be collected from the same plant over a period of three months.

Hawthorns are rather common throughout southwestern Manitoba, and of those near Morden and Brandon at least 95% are *C. chrysocarpa*. Since this is a rather variable species, much effort can be directed to trying to subdivide a complex genetic unit. Boivin (1967) places *C. chrysocarpa* under *C. rotundifolia* along with 10 to 12 species of some other floras. The most northerly collections seen by Scoggan place *C. chrysocarpa* nearly 320 km farther north than *C. succulenta*. The early flowering and fruiting of *C. chrysocarpa* suit a more northerly distribution and it appears to be the only hawthorn in much of Manitoba.

The characters that most usefully separate our two *Crataegus* species are listed in Table 2. *Crataegus succulenta*, the least plentiful species, is most easily located by finding late-blooming shrubs or trees and is less variable than *C. chrysocarpa* on the basis of our specimens. Identifications should be made on the basis of several characteristics, particularly in *C. chrysocarpa* because some specimens will disagree in some characters, but agree in most others. The variability in *C. chrysocarpa* is peculiar. This species seems to retain its identity in part while sharing a few characters with the other local species. The populations of it do not seem like the many hybrid swarms that have been reported where two or more species tend to merge or share all characters as with *Cypripedium* (Marshall et al. 1966), *Rosa blanda* and *R. woodsii* (Ziola and Dugle 1970), or *Populus* (Ronald et al. 1973).

Crataegus chrysocarpa seems to consist of a basic type to which other characters might have been added to perfect a system of acquiring genes that might be advantageous. The most uniform part of the group was a type with long slender, often branched, thorns and little pubescence, that formed low colonies in open dry sites. Others differed from this by characters that resembled the other local species. The larger stature and other characters of *C. succulenta* could have survival value in southern Manitoba where competition from trees and shrubs is greater than on most of the Prairies. A system such as this could help explain the complicated

TABLE 2—Characteristics useful for distinguishing between *C. succulenta* and *C. chrysocarpa*

	Crataegus succulenta	*Crataegus chrysocarpa*
Plant	Small tree with one to a few stems. Young wintering branches and thorns dark chesnut brown.	Many-stemmed shrub to occasionally a small tree. Young wintering branches and thorns gray-brown.
Leaves	⅔ expanded at flowering; 9–13 compound teeth on upper ½ of leaf, glands small, inconspicuous.	⅓ expanded at flowering; 7–11 large compound teeth on upper ⅔ leaf, glands on all teeth dark and distinct.
	Widest point above center of leaf (c/b* = 0.74). Leaf thick, somewhat leathery. Stomata length 31.5 μm.	Widest point below center of leaf (c/b* = 1.24). Leaf thin to medium thickness. Stomata length 37.2 μm.
Flowers	± 6 June (1971). Anthers dark reddish. Glands on sepals (and caducous stipules) distinct, stalked, green.	± 1 June (1971). Anthers light color. Glands distinct, dark, sessile.
Fruit	Mature ± 10 September (1971). Inner faces of seeds deeply pitted. These may be covered by a smooth, dark membrane. Seed length 6.0 mm. Ridges on outside of seed moderate size.	Mature ± 2 September (1971). Inner faces of seeds slightly rough or occasionally shallow to moderately deep pits. Seed length 6.5 mm. Ridges on outside of seed 2–4 heavy.

*c/b = measurement from widest point of the leaf to the tip/measurement from the base of the leaf to the widest point.

nature of the genus even beyond southern Manitoba. This would require an unusual genetic system but since the *Pomoideae* subfamily contains, besides diploid and tetraploid species, many triploid individuals and species that range from partially to fully fertile, there is evidence for unusual seedbearing systems (Darlington and Wylie 1955; Bolkhoskikh et al. 1969). One of the many forms of apomixis or near apomixis, such as occurs in the dog roses, could be involved.

The larger stomata size of *C. chrysocarpa* suggests that it has a higher chromosome number than *C. succulenta*. No counts were made from our specimens and available literature is of limited value. The two counts of 64 and 68 quoted by Bolkhoskikh et al. (1969) and Darlington and Wylie (1955) are both old, and the first is improbable since recent counts give x = 17 in the whole Pome tribe. They also list three triploids and a diploid species in series *Rotundifolia* but no member of series *Macracanthae*. It is probable that *C. succulenta* is diploid since its stomata length is among the shortest of 84 specimens of many species from our arboretum (unpublished data). It is not clear, from stomata length, whether *C. chrysocarpa* is triploid, tetraploid, or both, but all are compatible with its being a complex entity.

Because of the complexities of *C . chrysocarpa*, it is probably best to follow Boivin (1967) in using the broader specific term *C. rotundifolia*. Further study is needed on chromosome counts of hawthorns to determine the status of many species and on the methods of seedbearing which allow triploid, normally sterile, species to reproduce freely.

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Inter-island Movements of Peary Caribou South of Viscount Melville Sound, Northwest Territories

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Locations, directions, and destinations of Peary Caribou (*Rangifer tarandus pearyi*) trails across sea-ice of Peel Sound and Baring Channel between Somerset and Prince of Wales and Prince of Wales and Russell islands, respectively, were obtained during helicopter searches in June 1977. We also searched and counted Caribou on small islands in Peel and Viscount Melville sounds, which further indicated movements of Caribou from Somerset to Prince of Wales and Russell islands and probably north towards Bathurst Island. On sea-ice 158 trails were found and an additional 31 trails were seen on land adjacent to sea-ice crossings, which indicated inter-island movements had taken place. Those movements may be critical in restocking Bathurst Island, an important Inuit hunting area, and in rejuvenating the gene pool. The inter-island movements would likely be vulnerable to the potential disturbance of an all-year open-water tanker route to ship liquid natural gas from Melville Island to southern markets.

Key Words: Peary Caribou, inter-island movements, Northwest Territories, sea-ice trails, tanker route, wildlife disturbance, Arctic.

The possible need for free inter-island movements by Peary Caribou for the maintenance of the species on the Canadian Arctic Archipelago is now a matter of concern, as an all-year tanker route through the waters of Lancaster and Viscount Melville sounds has been proposed. An open sea lane for transporting liquid natural gas from eastern Melville Island to southern markets during the ice-bound period of the year has the potential for disrupting and possibly halting the free flow of Peary Caribou across Viscount Melville Sound. Unimpeded movements could eventually result in the recolonization of declining Caribou populations on islands north of Viscount Melville Sound, especially Bathurst Island (Viscount Melville Sound in this paper includes the water of Barrow Strait east to 95°00′W).

During June 1977 we documented the existence of trails of Peary Caribou, which indicated ice crossings by Caribou from Somerset Island to Prince of Wales Island, and north onto small islands of Viscount Melville Sound. Field time consisted of 11.7 h of searching coastal areas of Somerset, Prescott, Vivian, Lock, Prince of Wales, Mecham, and Russell islands by Bell-206 turbo-helicopter. Greater effort was not possible because of other commitments. The aerial searches were carried out on 12, 13, 17, and 18 June. Subsequent surveys by helicopter were made over Hamilton Island and Young Island on 15 August, Russell Island on 16 and 17 August, and Lowther Island on 25 August 1977. Hamilton and Young islands received full coverage, Russell and Lowther islands each about 50% coverage by flying coastlines and major drainages. The aerial searches were carried out under favorable light conditions which allowed us to see the cast of the trails for several hundred metres from the helicopter. We flew at low speeds (about 96 km/h) and 10–25 m above sea-level to search for trails. When we encountered a trail we hovered and/or landed to ascertain from the hoof imprints the direction of travel. We often flew along the trail for several kilometres to confirm the heading of the trail.

Observations and Discussion

In total 158 Caribou trails were found on sea-ice, which confirmed inter-island movements by Peary Caribou (Table 1 and Figure 1). An additional 31 trails were seen on land adjacent to sea-ice crossings, which indicated such movements had taken place (Table 1). The magnitude of the inter-island movements could not be ascertained, as we were not sure of the number of Caribou each trail represented. The trail that was backtracked across Peel Sound from Prince of Wales Island to Somerset Island divided into as many as 10 different trails during the crossing.

TABLE 1—Distribution of Peary Caribou trails on sea-ice demonstrating inter-island movements of Caribou on islands south of Viscount Melville Sound, Northwest Territories, June 1977

Islands		
Origin	Destination	No. trails[1]
June 12, 73°30′N, 73°00′N[2]	(Zone 3, Fig. 1)	
Prescott	Prince of Wales	(9) 6
June 13, 73°30′N, 73°00′N	(Zone 3, Fig. 1)	
Somerset[3]	Prince of Wales	(7) 2
Somerset[3]	Prescott	10
Vivian	Prince of Wales	2
Lock	Prince of Wales	1
June 17, 73°30′N, 73°00′N	(Zone 3, Fig. 1)	
Somerset	Prince of Wales	1
Somerset[3]	Prince of Wales	3
Somerset[3]	Prescott	7
Prescott[3]	Prince of Wales	6
Prescott	Vivian	11
Vivian	Lock	3
Lock	Prince of Wales	9
June 17, 73°00′N, 72°30′N	(Zone 4, Fig. 1)	
Somerset[3]	Prince of Wales	6
Somerset[3]	Prescott	4
June 17, 72°30′N, 72°00′N	(Zone 5, Fig. 1)	
Somerset[3]	Prince of Wales	24
June 18, 97°30′W, 98°30′W	(Zone 2, Fig. 1)	
Prince of Wales	Russell	11
June 18, 98°30′W, 99°30′W	(Zone 1, Fig. 1)	
Prince of Wales	Russell	(15) 17
Prince of Wales	Mecham	11
Mecham	Russell	21
Russell	Prince of Wales	3

[1]Values in parentheses are numbers of trails that were seen on inner bays and coastal areas that indicated inter-island movements but could not be traced to sea-ice for verification.

[2]Latitudinal zones (30′) are about 56 km wide, north to south; longitudinal zones (1°) are about 30 km wide, east to west.

[3]The origin for each of these trails was assumed, based on direction of travel and course on the sea-ice in relation to adjacent islands. All other embarkations and all landings were verified, see text.

As it is common behavior for Caribou to travel in single file during movements impeded by snow cover, it is likely that the 95 observed trails on Peel Sound could have been made by at least several hundred Caribou.

On 12 June we noted trails in the Back Bay area of Prince of Wales Island, which indicated a movement of Caribou into this area. On the chance that the Caribou had come off the ice of Peel Sound we searched the snow-covered ice of Back Bay and Browne Bay between 73°30′N and 73°00′N for evidence of ice crossings by Caribou (Table 1). We repeated our aerial search on 13 June and extended the area to include the satellite islands of Lock, Vivian, and Prescott (Table 1).

The weather deteriorated on 14 June and forced a halt to aerial work until 17 June when our search included the area along the east coast of Prince of Wales Island from 73°30′N south to about 72°00′N (Cape Eyre) (Table 1). Observations indicated that a major movement of Peary Caribou from Somerset Island to Prince of Wales Island had taken place between 11 and 17 June.

Cow–calf pairs did not show up on the north coast of Prince of Wales Island until 23 June. Numbers of all sex and age groups increased in this area throughout the remainder of June. Therefore, it is likely that across-ice movements, especially of cows and newborn calves, continued after 17 June.

On 18 June we searched the north coast of Prince of Wales Island, the snow-covered ice of Baring Channel, and the coast of Mecham Island and Russell Island between longitudes 97°30′W and 99°30′W (Table 1 and Figure 1). Our findings indicated that Caribou had moved north off Prince of Wales Island several days prior to our search, most likely sometime around 13–16 June.

Trails on the north coast of Russell Island led onto the sea-ice of Viscount Melville Sound in the general direction of Young, Lowther, and Bathurst islands. Deteriorated ice condition did not allow us to follow the Caribou tracks northward on Viscount Melville Sound.

One set of trails was followed from Prince of Wales Island for about 50 km across Peel Sound to Somerset Island on 17 June (Table 1). The six trails from Prescott Island were followed to Prince of Wales Island on 12 June (Table 1). The six trails seen coming off Prescott Island on 17 June (Table 1) were not followed, but they left the island in the same area as the trails seen on 12 June and coursed across the sea-ice in the same

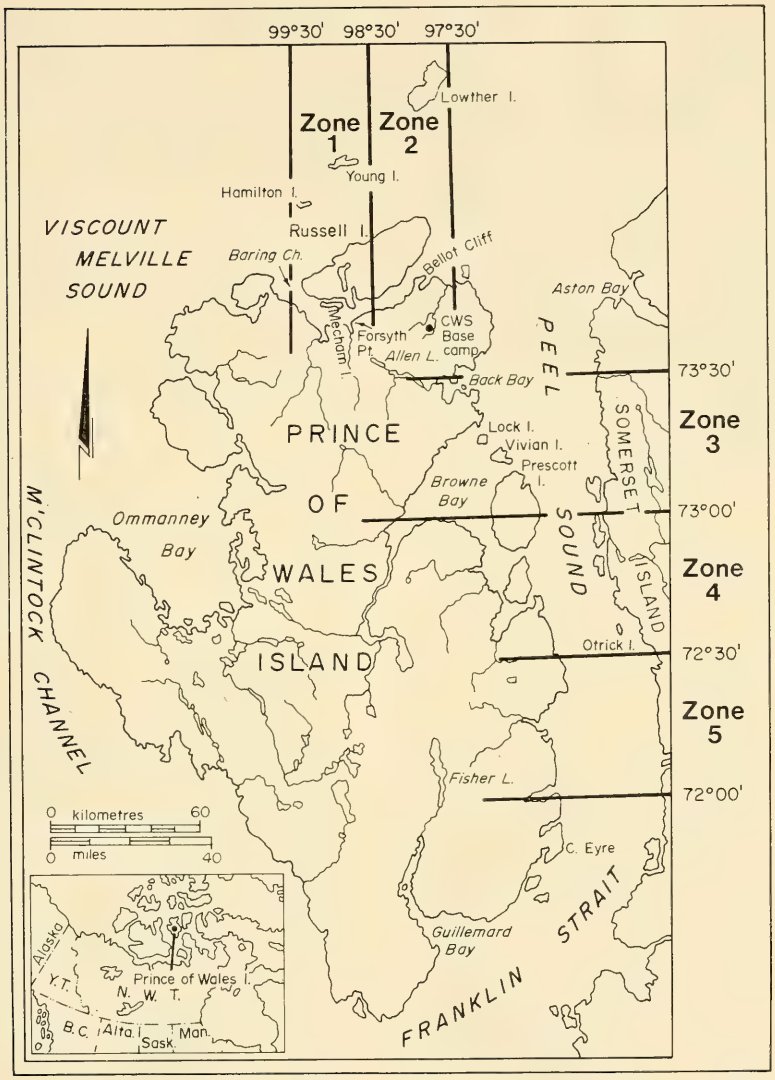

FIGURE 1. Latitudinal and longitudinal locations of Peary Caribou trails on sea-ice demonstrating inter-island movements of Caribou on islands south of Viscount Melville Sound, Northwest Territories, June 1977 (distributions of trails are given by zone in Table 1).

direction as the previous trails. As there were no trails seen going onto Prescott on that occasion, there was no reason to believe that those animals had not also moved to Prince of Wales. All trails were followed from Prescott to Vivian, from Vivian to Prince of Wales and/or Lock, and from Lock to Prince of Wales (Table 1).

Inter-island movements from Prince of Wales to Russell and/or Mecham islands (Table 1) were verified by flying along the north coast of Prince of Wales and determining where trails left the coast and their course on Baring Channel, then flying along the south coasts of Russell and Mecham to determine the course of trails coming off the sea-ice. The points of departures and arrivals onto the land for trails from Mecham to Russell Island (Table 1) were located by flying along the north coast of Mecham and

the south coast of Russell Island (the narrowness of the channel allowed us to see the entire length of the trails).

Only the origins of 56 trails that we assumed to have originated on Somerset Island and that were located coming onto Prince of Wales and Prescott islands were not verified by our flying along their entire courses. We first flew 300–500 m off and parallel to the east coast of Prince of Wales and Prescott islands to locate and determine directions of trails coming off Peel Sound; during our return flight we were about 10 km off and parallel to those same coasts to confirm the persistence of the headings of the trails. As there is no land east of where we could last see the trails until Somerset Island it is reasonable to believe the trails left from Somerset.

We saw no Caribou on Hamilton Island during August, but found winter droppings. We found 22 Caribou, two of which were calves, in six groups on Young Island in August and 334 Caribou in 85 groups on Russell Island, calves representing 21.8% of this total. Earlier searches of Russell Island on 18 June suggested much fewer Caribou were on the island at that time. On Lowther Island in August there were 20 Caribou, four of which were calves in five groups. We suggest that the Caribou on Young and Lowther islands in August had moved to those islands in June 1977 probably from Russell Island.

Recurrence of freezing temperatures during the earlier stages of the spring thaw result in formation of ice within the snow cover, which makes low-growing forage unavailable to Caribou. Thus, during the spring period of icing, feeding on snow-covered areas remains either nearly impossible or is accomplished with high energy costs which probably often exceed energy intake. Perhaps this difficulty in obtaining forage may trigger long-range movements or migrations of Peary Caribou. Pruitt (1959) reported that heavy crusting on deep snow, which hindered or prevented foraging, served as a stimulus for springtime migrations of Barrenground Caribou on the Canadian mainland. Heavy crusting of deep snow (>60 cm) over soft snow also provided a strong bearing surface which allows Caribou to travel with relative ease.

Inter-island movements of Peary Caribou on western Queen Elizabeth Islands were documented in 1974 by Miller et al. (1977b). Earlier evidence based on Inuit kowledge of inter-island movements of Peary Caribou among the islands reported herein are given in Manning and Macpherson (1961), Bissett (1968), Freeman (1975), and Riewe (1976).

We also heard reports from the Inuit of inter-island movements among Somerset, Prince of Wales, and Russell islands (G. Eckalook, personal communication). During seal surveys in Peel Sound and Barrow Strait, T. G. Smith (personal communication) noted Caribou tracks on sea-ice. In May 1975, Smith saw one track going east to west near Otrick Island (72°37′N, 95°35′W), 10 Caribou going west across Peel Sound from Somerset Island, 30 Caribou along the west Somerset Island coast, and at least six tracks toward Back Bay, Prince of Wales Island from Somerset Island. In May 1976, Smith saw three Caribou in Aston Bay moving west.

Bathurst Island is a traditional hunting area for the Inuit of Resolute Bay, Cornwallis Island (Bissett 1968; Freeman 1975; Riewe 1976). Numbers of Peary Caribou on western Queen Elizabeth Islands, especially Bathurst Island, are currently low (Miller et al. 1977a), and the Inuit have already voiced their concern over the declining number of Caribou. They voluntarily suspended hunting on Bathurst Island in 1974, and now have to travel further afield to hunt Caribou on Somerset and Prince of Wales islands. Re-establishment of Peary Caribou on Bathurst Island (which would satisfy the needs of Inuit from Resolute Bay) at recently estimated rates of reproduction and survival (Miller et al. 1977a) would probably require recolonization from other islands. Recolonization of Bathurst by Peary Caribou is most likely to occur by movements of Caribou from Somerset and Prince of Wales islands across Viscount Melville Sound. An influx of Caribou to Bathurst Island from the west is unlikely as their numbers are also currently low on both Melville and Prince Patrick islands (Miller et al. 1977a).

The apparent existence of traditional migrations and environmentally forced seasonal movements by Peary Caribou to maintain themselves as a species on the Canadian Arctic Archipelago require that the phenomenon of

inter-island movements be studied further. Such an investigation would provide insight into the potential for restocking of Peary Caribou on Bathurst Island by recolonization from Somerset and Prince of Wales islands, a matter of concern to the Inuit of Resolute Bay. The work would also provide an evaluation of the possible detrimental effects of an all-year tanker route through Viscount Melville Sound on recolonization movements across sea-ice by Peary Caribou.

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Supplementary Information and Viewpoints

What Causes Inter-island Movements

An example of the complexity of evaluating data in isolation is seemingly given by a comparison between Freeman's (1975) report of Caribou movements from Bathurst Island and our own observations of the same events (Miller and Russell 1976). Freeman (1975) reports that distributional changes occurred among Caribou on Bathurst Island starting in 1973 and culminated in spring 1974 with movements from the island. He infers that the intra-island movements and exodus of Caribou were unexpected and were caused by seismic and associated exploratory activity. We (Miller and Russell 1976) also detected the movements of Caribou (some Muskoxen also made the move) from Bathurst to Little Cornwallis then to Cornwallis Island in the spring of 1974. The distribution of Caribou on Bathurst in late winter 1973 (Miller and Russell 1975, 1976) was as expected, that is, as described for that season of the year by Inuit from Resolute Bay (Bissett 1968), so that the unexpected movements reported to Freeman must have occurred in the winter of 1973–1974, which was a particularly severe winter. Snows came early and accumulated rapidly in early winter 1973–1974, and deep snow cover persisted into late June and early July in some areas. Also, groundfast ice put down by freezing rains in September and October most likely occurred over extensive areas (Miller and Russell 1975; Parker et al. 1975).

Subsequently, mortality among Caribou on the easterly islands of the western Queen Elizabeth Group was high and movements were varied (Miller and Russell 1975, 1976; Parker et al. 1975). We do not dismiss Freeman's (1975) supposition as being totally untenable, but we do suggest that movements of Caribou from Bathurst in the spring of 1974 and possibly earlier intra-island movements in 1973 were caused by restricted and unavailable forage supplies, a condition that was nearly universal on many western Queen Elizabeth Islands at that time (Parker et al. 1975; Miller and Russell 1976). The possibility exists that exploratory activities could have intensified the situation on Bathurst, but the data for the western Queen Elizabeth Islands complex supports more the argument for natural catastrophe as the causative agent.

Both Bissett (1968) and Freeman (1974. Environmental report, Bathurst Island, N.W.T. Part 1, Caribou. Inuit Land use and occupancy Project, typescript Ms. 12 pp.) have documented Inuit reports of Peary Caribou seasonally occupying small islands off Bathurst. We contend that the movements of Caribou from Bathurst to Little Cornwallis to Cornwallis and to other islands have existed for aeons, but that their existence was masked by the relatively high numbers of Caribou present on Bathurst Island in the late 1950s until the mid 1970s. Peary Caribou numbers were declining throughout the 1960s on western Queen Elizabeth Islands; therefore, the magnitude of many movements would have been decreasing unless reinforced by severe environmental conditions, which was the case in 1974.

Although Freeman (1975, Table 3) shows that more Caribou were taken on Cornwallis in 1973–1974 than during the 3 yr before, he also shows that the number of hunts had increased considerably on Cornwallis (supposedly out of necessity, owing to lack of Caribou on Bathurst, but possibly also because of an awareness of Caribou on Cornwallis in

1974). The average number of Caribou taken per hunt during all years on all islands, however, is not very dissimilar. In fact, average success per hunt on eastern Bathurst was higher in 1971–1972 than in later years when the dependency supposedly shifted to that area of Bathurst. There is no doubt that the Caribou declined drastically on southern Bathurst during 1973–1974 and that the Caribou movement to Cornwallis was marked in the spring of 1974, but the causes remain debatable as does the stability of the dynamics associated with the situation.

This discussion serves mainly to stress the need for more baseline data. We concur with Freeman (1975) that the Inuit possess "a considerable stock of basic, empirical knowledge" that should not be overlooked. But we also suggest that the 17 yr when Inuit of Resolute Bay have hunted on Bathurst Island is not enough time for them to possess a full knowledge of the long-term dynamics of the Caribou there. We think this supposition is sound because existing data (Macpherson 1961; Tener 1963; Miller and Russell 1976) indicate that (1) Peary Caribou were in high numbers and possibly peaked about the time Inuit from Resolute Bay began hunting on Bathurst; and (2) that condition was followed by an apparently continuous, general decline (unrelated to hunting or exploratory activities) in Caribou numbers on Bathurst and all other islands, at least, of the western Queen Elizabeth Group, since that time until present (Miller and Russell 1976).

Evidence for Inter-island Movements of Caribou

Most descriptions of Peary Caribou movements across sea-ice between islands of the Arctic Archipelago are based on circumstantial evidence rather than direct observations. The earliest mention of movements between islands was by Parry (1821, p. 110). From his observations of an increase in Caribou numbers near Winter Harbour, Melville Island, in October and when he subsequently saw only one or two during the winter, Parry assumed that the Caribou migrated south and returned in May. Parry's conclusion was refuted by Bernier (1910, p. 98) who also overwintered at Winter Harbour. He failed to observe tracks on the ice within 60 km east and 90 km west of Winter Harbour. Although Bernier commented on the increase in numbers in September and October in the vicinity of the ship he saw Caribou in the winter and suggested that there was no migration. But the geologist for the expedition, McMillan (*in* Bernier 1910, p. 475) noted that Caribou "tracks are frequently seen upon the ice and herds have been seen crossing from one island to another," but gave no further details. McDougall (1857, p. 398) noted ". . a party of 5 deer . . ." travelling to the east across McDougall Sound between Bathurst and Cornwallis islands on 25 May 1854. Peary (1907) hunted Caribou on both sides of Nansen Sound, between Axel Heiburg and Ellesmere islands, which led Allen (1908, p. 491) to suggest that Nansen Sound must be passable for Caribou for most of the year.

In reporting on his explorations of the western islands of the Queen Elizabeth Group, Stefansson (1921) described inter-island movements of Caribou. He noted (p. 399) ". . . that many caribou do leave the island [Banks] most falls, if not every fall, going south to the mainland." The observation in September 1915 of Caribou tracks 5 km south of Jenness Island, a small island off south Borden Island is one of the few instances in the literature of direct evidence of inter-island movements.

Inter-island movements of Peary Caribou between the Queen Elizabeth Islands have been assumed in description of taxonomy and changes in population size. Manning (1960, p. 43) thought that the available specimens of Peary Caribou from the Queen Elizabeth Islands suggested a fairly homogenous population. Homogeneity would be expected, if, as Manning suggested, Caribou crossed between islands with no difficulty. Macpherson (1961, p. 12) suggested that inter-island movements were the explanation of changes of numbers of Caribou on Borden, Brock, and Mackenzie King islands observed by Stefansson (1921) and geologists in 1958–1959. Tener (1963) found tracks leading from Mackenzie King to Borden Island in August 1961. He suggested the high density on Borden might be partly the result of immigration.

More has been documented on movements of Caribou among and between the larger islands south of McClure Strait, Viscount Melville Sound, and Barrow Strait, and the mainland. Manning (1960) had collected and described evidence of inter-island movements across the ice between the mainland and Banks Island and Victoria Island in fall and spring. He suggested that it is unlikely that McClure Strait between Banks and Melville and Prince Patrick islands is crossed because the ice freezes late and is probably rough. Manning and Macpherson (1958, pp. 66–67) and Manning (1960) thought the crossing between Banks Island and the mainland was not a regular movement. McEwan (1955) described a movement from Banks Island to the mainland and west coast to Victoria Island in 1952; he also noted that Caribou moved onto the sea-ice in October. They remained on the ice for a "considerable length of time," and few returned to Banks. Armstrong (1857), while overwintering on the *Investigator* in Prince of Wales Strait, 1850–1851, saw Caribou cross between Banks and Victoria islands. McClure (1856, p. 156) described one of the instances of movement: a seaman was out walking from the *Investigator* in January 1851, "And pass close to him a small herd of reindeer trotting quickly towards the Princess Royal Islands." The movement between Victoria Island and the mainland was an extensive migration. Reference to it was made by Franklin (1823, p. 395) and Sabine (*in* Franklin 1823, p. 665) while they were exploring Bathurst Inlet. Later descriptions by Rae (1850), Collinson (1889), and Hoare (1927) were brought together by Manning (1960). He described the timing, numbers involved, and eventual destruction of the migrating herds by firearms in 1919. Manning (1960, p. 47) considered Caribou of the so-called Dolphin and Union herd that migrated between Victoria Island and the mainland were more closely related to Barren-ground than to Peary Caribou. Movements between Prince of Wales and Somerset islands across Peel Sound are known by Eskimos (Manning and Macpherson 1961, p. 219; Bissett 1968, p. 125). Manning and Macpherson (1961, p. 219) saw Caribou tracks crossing Browne Bay on the east side of Prince of Wales Island.

Movements across the ice are known for other populations of *Rangifer*. Vibe (1967) cites a Greenland Eskimo who encountered far out on the sea-ice. Caribou which looked different from the Greenland Caribou and were assumed to have come from Baffin Island. Banfield (1961) indicated that the Peary Caribou of northwestern Greenland could have

colonized from Ellesmere Island across the frozen Kennedy Channel. Banfield (1961, p. 105) suggests movements across ice to explain the distribution of other subspecies after glacial periods.

Some of the most extensive movements of *Rangifer* across sea-ice have been documented in the Soviet Arctic (Nasimovich 1955; Banfield 1954, 1961). Nasimovich (1955, pp. 176–181) gives examples of movements of wild reindeer between the northern and southern islands of Novaya Zemlya, and wild reindeer moving out onto the Kara Sea even to Yamal on the mainland, about 300 km away. Wollebaek (1926) reported that reindeer marked on Novaya Zemlya were shot on Spitzbergen, a minimum distance of about 770 km. Nasimovich (1955) described seasonal movements of wild reindeer between the mainland and Belyi and other small islands; they summer on the islands and return to the mainland in the fall.

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Response of White-tailed Deer to Snowmobiles and Snowmobile Trails in Maine

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During three winters of 1972–1975 in Somerset County, Maine, we studied White-tailed Deer (*Odocoileus virginianus*) use of a 17-km snowmobile trail system. Use was significantly correlated with deer density (as determined by pellet group counts) and with winter severity. Temperature, wind, snowfall, and deer sinking depth in snow was used as the winter-severity index. Most deer followed snowmobile trails for short distances and used them near major bedding areas. Disturbance of deer by snowmobiles did not cause them to abandon preferred bedding and feeding sites. Sinking depth of deer on snowmobile trails was significantly less than off trails and was inversely correlated with hardness of snowmobile trails. They traveled and fed along 9.1 km of snowmobile trails made in openings adjacent to existing concentration areas. Deer were induced to move up to 1.9 km by use of snowmobile trails, cedar foliage, and chain-saw noise. Deer ran from snowmobiles or stayed in place; the response varied between winters, within winters, with time of day, cover type, proximity to deer trails, snow depth, and deer sinking depth in snow but not with temperature or deer group size. Deer management could be enhanced by use of snowmobiles.

Key Words: White-tailed Deer, snowmobiles, climate factors, snow characteristics, Maine.

Since their commercial debut in 1959, snowmobiles have become popular in North America. Originally used as work vehicles by utility companies, snowmobiles today are used primarily for winter recreation (Baldwin and Stoddard 1973). Many people have used them to travel into remote areas which were previously undisturbed by man in winter.

Snowmobiling in remote woodlands initiated controversy over the effect of such activity on wild animals, especially White-tailed Deer. Some adverse effects of snowmobiling on wintering deer include harassment and running of deer to exhaustion (Wettersten 1971; Heath 1974), disruption of normal home ranges and activity patterns (Kopischke 1972; Dorrance et al. 1975), and depredations by feral dogs (Doherty 1971) traveling on snowmobile trails. Yet some snowmobile clubs in Minnesota and Ontario have deliberately created trails in deer wintering areas to improve deer mobility and feeding conditions (Wettersten 1971; L. D. Mech, 1972, North Central Forest Experiment Station, St. Paul, Minnesota). Doan (1970) suggested that the maintenance of snowmobile trails in deer wintering areas may be a valuable management tool for reducing overwinter deer malnutrition and mortality.

Many researchers (Severinghaus 1947; Banasiak 1964; Verme and Ozoga 1971; Kropp 1974; Drolet 1976, and others) have shown that White-tailed Deer activity varies with the prevailing winter weather conditions; temperature, wind, snow depth, and the support quality of snow appear to be the major weather factors involved. Therefore, we obtained data on these factors better to understand information gathered on deer response to snowmobiles and snowmobile trails. The objectives of this study were (1) to determine the extent deer used snowmobile trails and the environmental conditions associated with such use, (2) to assess the value of altering deer mobility by use of snowmobile trails, and (3) to measure deer response to snowmobiles.

Study Area

The study area was on the eastern edge of the White Mountain Plateau within Somerset County, Maine, at about 45° 15′N and 70° 10′W. The area is interspersed with abrupt rocky hills, ponds and streams, within the Dead River watershed. The mean annual snowfall is 293 cm and snow covers the ground an average of 124 d

[3]The U.S. Fish and Wildlife Service, University of Maine, Maine Department of Inland Fisheries and Wildlife, and the Wildlife Management Institute, cooperating.

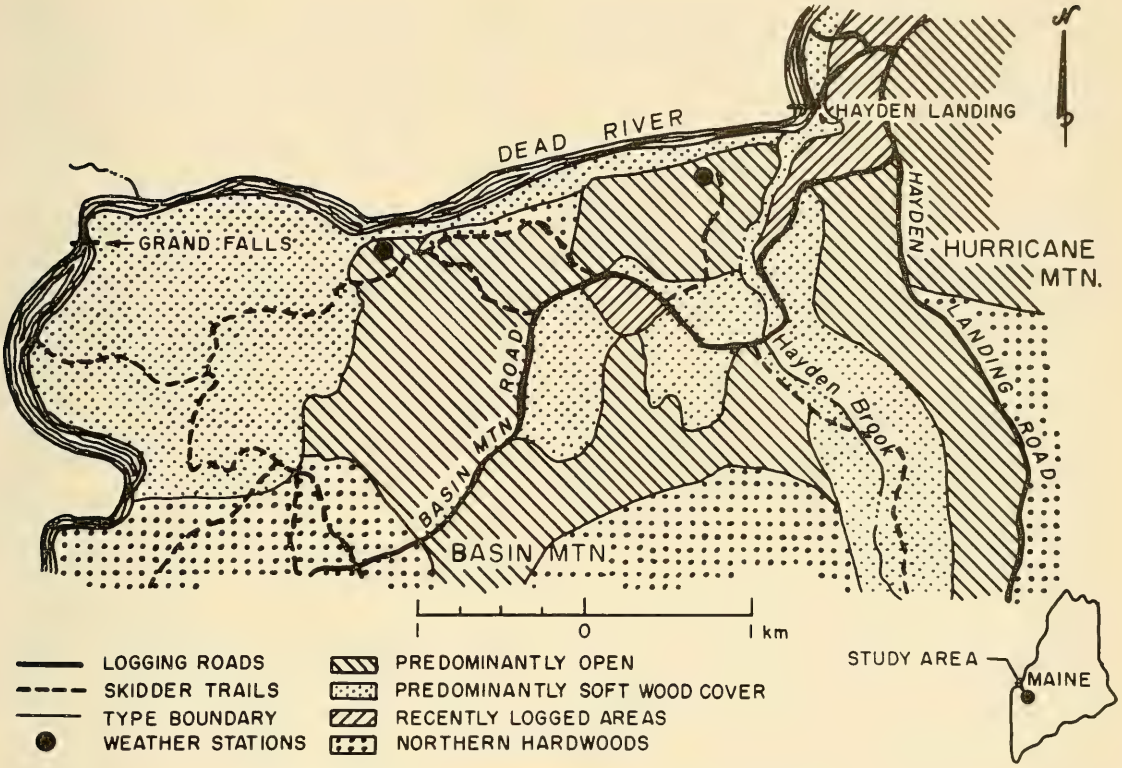

FIGURE 1. Hayden Brook deer wintering area, 1972–1975.

each year. The predominant soils are shallow stony loams which are strongly acid and have developed from glacial till (Lull 1968).

Logging has produced a complex cover which we divided into four basic types relevant to deer mobility (Figure 1). Some areas were logged early in the winters of 1970–1971 and 1971–1972. Snow is often deep in this type and little deer browse is available since there are usually few seedlings and/or sprouts above the snow surface.

Softwood stands are dominated by Red Spruce (*Picea rubens*), Balsam Fir (*Abies balsamea*), and White Cedar (*Thuja occidentalis*). This habitat type provides excellent shelter and mobility for the deer, but little food.

Brushy clear-cuts interspersed with many small patches of softwoods constitute the open-cover type; this type sometimes furnishes abundant browse but has deep snow which impedes deer travel. Various seral stages are present with such dominants as Red Raspberry (*Rubus idaeus*), Mountain Maple (*Acer spicatum*), Pin Cherry (*Prunus pensylvanica*), and Quaking Aspen (*Populus tremuloides*). Forest succession has been delayed in some openings because of over-browsing by deer and Moose (*Alces alces*).

The hardwood type is dominated by Red Maple (*Acer rubrum*), Sugar Maple (*Acer saccharum*), American Beech (*Fagus grandifolia*), and Yellow Birch (*Betula lutea*), but White Ash (*Fraxinus americanus*), Paper Birch (*Betula papyrifera*), and Eastern Hemlock (*Tsuga canadensis*) are common components. Varying quantities of browse are present in the understory of these stands, but deep snow and poor shelter often limit use by deer.

Field work was conducted in the Hayden Brook deer wintering area (Figure 1) in T3R4 and Pierce Pond townships. The wintering area includes the northern slope of Basin Mountain, the western end of Hurricane Mountain, and the adjacent lowlands; it lies between 335 and 430 m

above mean sea level. There are numerous logging roads and skidder trails of various ages and condition, but these received little use by snowmobilers, except at the extreme eastern end of the study area.

Methods

Field work was conducted from 1 December to 30 April during the winters of 1972–1973, 1973–1974, and 1974–1975. Snowmobiles were used for travel and trail-making on the study area as well as for moving equipment and cedar browse on sleds.

Distribution of deer was determined from weekly field observations. The deer population and density were estimated at the end of each winter, based on pellet-group counts (Ryel 1971). Deer pellet groups were counted and tabulated by cover type and location (Lavigne 1976).

Two weather stations, each with a hygrothermograph and a totalizing anemometer were serviced weekly in open habitat. A weighted mean-weekly temperature was calculated (Hugie 1973) and differences between weekly anemometer readings gave kilometers of wind per week. Snow depth was measured weekly at five sampling points near each station. Data on daily snowfall were obtained from records of Central Maine Power Company at Long Falls Dam. The depths that 10–15 deer sank into snow were periodically measured on and off snowmobile trails, in open and softwood cover types.

A Winter Severity Index (WSI) for quantifying winter harshness for deer, as developed by Banasiak (1962; Deer yard evaluation, Maine Department of Inland Fisheries and Game, Pittman-Robertson Project W-37-R-12, Job B-3, Mimeo, 7 pp.) and modified by Hugie (1973) was used as follows:

$$WSI = \left[(0.42)\frac{SF_s}{SF_m} + (0.22)\frac{SD_s}{SD_m} + (0.17)\frac{T_m - (T_s - T_m)}{T_m} + (0.19)\frac{W_s}{W_m} \right] 100$$

where s = seasonal value, m = long-term mean, SF = total annual snowfall, SD = mean deer sinking depth in snow of open habitat, T = weighted mean temperature, W = total kilometers of wind, (No.) = coefficients calculated for this study area by Hugie (1973). The WSI was calculated weekly and for the entire winters. Data for the study area from 1970–1975 constituted the long-term means used. A WSI of 100 was considered a normal winter, above 100 more severe, and below 100 less severe than normal.

Evaluation of Snowmobile Trail Use by Deer

Deer use of snowmobile trails was evaluated on a 17.1-km trail system during six periods each of the first two winters and nine periods in 1974–1975. Trail use was recorded as light (1–3 deer) or heavy (> 3 deer); the distance travelled by each group of deer was measured and the distances of the various groups were summed. Deer trails crossing the snowmobile trail were counted as "crossing trails," or "incorporated trails" (deer trails that followed 6 m or more of the snowmobile trail before crossing). The trail system was divided into 23 segments based on topography, cover type, and logging road width. The use of each segment was determined weekly and a Use Index (UI) was calculated as follows:

$$UI = \frac{(2\ HU + 1\ LU)\ 100}{(HU + LU + NU)}$$

where HU = number of times heavy use was recorded, LU = number of times light use was recorded, NU = number of times no use was recorded. A UI of 200 represented consistently heavy use by deer, 100 consistently light use, and a value of 0 indicated no use.

Snowmobile trail hardness was measured during the last two winters with a Rammsonde penetrometer (Anonymous 1970). Hardness was determined at seven locations on the trail route with five measurements, spaced 6 m apart, at each location.

During the winter of 1972–1973, 10 attempts were made to change the foci of groups of deer. In each attempt, a snowmobile trail was made from their center of activity to a new location where 10 cedar trees were felled at the end of the trail with an axe or chain saw. The snowmobile trail alone; the snowmobile trail and cedar foliage placed along it; or the snowmobile trail, cedar foliage, and chain-saw noise were used to induce the deer to the new location.

In the winter of 1974–1975, 10 snowmobile

trails totaling 9.1 km, were established between concentration areas and potential feeding areas as loops, grids, dead ends, and open ends (trails that joined two main snowmobile trails). Trail use was evaluated at 1-d or 2-d intervals.

Deer Response to Snowmobiles

Deer encounters with observer snowmobiling were classified as (1) deer seen on the snowmobile trail or (2) deer seen away from the snowmobile trail. The reaction of deer to the observer on foot was also recorded. Deer were recorded as running out of sight or staying in place. Deer encounters for all three winters were pooled to increase sample size, and chi-square tests were used to determine whether deer response deviated from the expected.

Results and Discussion

Deer Use of Snowmobile Trails

Deer used a 17.1-km trail system an average of 8.1 km per evaluation period during 1972–1973, 2.8 km during 1973–1974, and 4.0 km during 1974–1975. This between-year variation in deer use was caused, in part, by yearly differences in deer density in the wintering area. Deer tended to follow snowmobile trails farther in early and late winter than in mid-winter. This coincides with the general pattern of activity that Silver et al. (1969), Ozoga and Verme (1970), and Kropp (1974) found in penned deer.

Most deer used snowmobile trails for short distances, seldom following them farther than 0.2 km in their daily movements. Deer often left the trails to feed, and returned to them elsewhere. For snowmobile trails in general, deer commonly used them as travel routes connecting deer trails. Yet, even under adverse snow conditions, deer sometimes crossed snowmobile trails instead of following them, especially when such trails were oriented at 90 degrees to the direction deer generally moved.

Sinking depths of deer off snowmobile trails in open, hardwood, and mixedwood habitats were each greater ($P < 0.05$) than in softwood habitat but deer sinking depths on snowmobile trails tended to be similar in all cover types. Sinking depths off snowmobile trails were greater ($P < 0.05$) than on snowmobile trails in all cover types, as determined by Student's *t*-test. Deer sank an average of $1/10$ to $1/2$ as much on snowmobile trails as off trails and never approached depths which seriously impeded their mobility. Neumann and Merriam (1972) also found that animals sank much more deeply off than on snowmobile trails at four sites in southern Canada. Deer sinking depths were also more variable off than on snowmobile trails since snowmobiles tend to eliminate some of the natural snow differences.

Mattfeld (1973) determined that the energy expended by tame deer walking in snow, in New York, increased greatly with increasing sinking depth, and that non-supporting crusts further increased the energy deer expended in traveling. These results should apply also to wild deer in western Maine. Thus, because of their continuous packed surface and excellent deer supportability, snowmobile trails greatly reduce energy expenditure of travelling deer. Doan (1970) believed the presence of a strategically located snowmobile trail system in a deer wintering area could improve over-winter deer survival; our observations support this belief.

Mean hardness varied considerably by day, from 199 kg when the trail was icy to 2 kg when it was slushy. In contrast, Neumann and Merriam (1972) recorded no penetrations of snowmobile trails in the Ottawa area with a loading less than 200 kg; this difference in trail hardness was probably due to differences in snowmobile traffic, although snow characteristics may also have differed between areas. No snowmobile trail was harder ($P > 0.05$) than any other in our study. Air temperature and time since sunrise were poorly correlated with snowmobile trail hardness ($r = 0.36$) but this was probably owing to imprecise measurements.

Deer sank considerably deeper in snow from noon to midnight than from midnight to noon in the spring. Deer sinking depths on snowmobile trails also differed during these times but to a lesser degree. Sinking depths on snowmobile trails in all cover types were inversely correlated ($P < 0.05$) with snowmobile trail hardness ($r = -0.58$ to -0.78).

Relation of Climatic Variables to Deer Use of Snowmobile Trails

Climate

Deer used snowmobile trails more as the severity of winter weather increased and certain aspects of snowmobile-trail use by deer were directly correlated with weekly WSIs (Table 1).

TABLE 1—Correlation of snowmobile trail use by deer with winter severity indices in the Hayden Brook wintering area, 1972–1975. Sample sizes are in parentheses; * indicates significance at 0.10 level and, ** significance at the 0.05 level

Aspects of snowmobile trail use	1972–1973 (6)	1973–1974 (6)	1974–1975 (9)
Total km traveled by all deer	0.73**	0.66**	0.45
Total km traveled by 1–3 deer	0.01	0.77**	0.06
Total km traveled by > 3 deer	0.82**	0.18	0.54*
Mean km traveled by 1–3 deer	0.45	0.36	0.28
Mean km traveled by > 3 deer	0.71**	0.05	0.74**
Number of deer trails	0.47	0.24	0.18
Number of deer trails that crossed the snowmobile trail	0.24	0.16	0.09
Number of deer trails that followed 6 m of the snowmobile trail before crossing	0.52	0.33	0.35
Number of deer tracks crossing the snowmobile trail	–0.73**	0.74**	–0.25
Track/trail ratio	–0.63*	0.32	–0.22

The total distance traveled by all deer on snowmobile trails was significantly correlated with weekly WSIs during 1972–1973 ($P < 0.05$) and 1973–1974 ($P < 0.10$). Total distance of snowmobile trails lightly used by deer was significantly correlated ($P < 0.05$) with weekly WSIs during the winter of 1973–1974, when deer were widely distributed at a low density. Total and mean distances of snowmobile trails heavily used by deer were significantly correlated with weekly WSI values during 1972–1973 ($P < 0.05$) and 1974–1975 ($P < 0.10$) when deer were more confined and more abundant on the study area. The differences in the weather and hence in the WSIs are reflected in differences in use of snowmobile trails by deer.

In spite of yearly and monthly differences in deer density and distribution in relation to snowmobile trail location, deer reliance upon snowmobile trails for travel appeared to be inversely proportional to their off-trail mobility. Deer were inactive during snow storms and for 24–72 h after a storm when the snowfall exceeded about 15 cm. When they again became active, they often followed snow-covered snowmobile trails rather than crossing adjacent trail-less snow or using snow-filled deer trails, as noted by Hugie (1973).

Deer distribution and density

During each winter the six most intensively used segments of a 17.1-km snowmobile trail system were those located near major bedding areas. The mean UI for these trail segments was 138 during 1972–1973, and 122 in 1974–1975; the UI was only 90 and 68 for all segments during those winters. The relatively low UIs for trail segments near bedding areas in 1973–1974 was due to the excellent off-trail snow support for deer that winter. Deer generally used snowmobile trails near bedding areas daily, all winter, as a travel route to feeding sites. Thus, the heavily-used trail segments functioned as an extension of the deer trail system.

Snowmobile trails on wide logging roads were used rather sporadically by deer. Mean UIs for segments A through M were 80, 92, and 44 during the successive winters, suggesting light use of wide logging roads (Lavigne 1976). The absence of browse, the exposure of deer to wind, the drifting-in of snowmobile trails by snow, the distance from deer feeding and bedding areas, and the presence of nearby sheltered deer trails apparently influenced deer to avoid these segments. Gill (1957a) and Banasiak (1964) pointed out that deer prefer to travel on sheltered trails in winter.

Changes in the UI for the trail segments were also related to shifts in deer distribution and density. For example, segments C through G declined from a UI of 102 to 78 to 44 through the winters, coincident with declining food and decreasing deer use of the logged area. Also, segments L and M bordered a large section of essentially open habitat containing much deer food usually covered by snow, and hence normally not available to deer in winter. But because of the light snowfall in the winter of 1973–1974, the UI was 134 compared with 38 and 64 the first and third winters, respectively.

We suspect, however, that deer use some snowmobile trails through habit rather than need as suggested by Gill (1957b) for deer trails. For instance, snowmobile trails near bedding areas were used daily and heavily by deer, even when surface snow crusts supported them. That deer traveled on snowmobile trails at all during the mild winter of 1973–1974, seemed to be from habit.

Deer pellet groups were counted on mil-acre (0.001-acre or 0.000405-ha) plots; there were 0.92 groups per plot in recently-logged habitat, 0.70 in softwood, and 0.34 in open habitat in 1972–1973. The corresponding figures for 1973–1974 were 0.26, 0.18, and 0.32, and 0.48, 0.30, and 0.42 in 1974–1975 (the deer population in the wintering area was estimated to be 478 ± 60, 305 ± 64, and 389 ± 69 in successive years). The mean total distance traveled by all deer using snowmobile trails was correlated ($P < 0.10$; $r = 0.98$) with mean density of deer pellet groups per mil-acre plot. There were not sufficient plots in hardwood habitat to obtain acceptable figures.

Large openings with considerable browse were generally little used by deer except along the edges where they developed an extensive trail system. Openings that were penetrated by deer trails usually seemed to have large amounts of browse and scattered clumps of softwood trees that the animals used for bedding sites; however, the degree of browse exploitation in the openings as a whole was usually low.

Disturbances by humans

Abrupt changes in deer activity could be accounted for by changes in snow supportability, and did not appear to be related to snowmobile disturbances. Deer consistently bedded near snowmobile trails and fed along them even when those trails were used for snowmobiling several times daily. In addition, fresh deer tracks were repeatedly observed on snowmobile trails shortly after machines had passed by, indicating that deer were not driven from the vicinity of these trails. We did not, however, have any heavily-used snowmobile trails. In Wisconsin, Bollinger et al. (1973) found that deer home-range size and activity patterns did not differ significantly between a wintering area with heavy snowmobile use and one receiving no use. But in Minnesota, Dorrance et al. (1975) concluded that deer home-range size, daily movement, and distance from snowmobile trails in Minnesota increased with increasing snowmobile activity. Since we had no trails with heavy snowmobile traffic it is conjectural whether we would have obtained results like those in Wisconsin or like those in Minnesota.

Deer mobility

During the winter of 1972–1973, deer were successfully moved from traditional exploited localities to relatively unused localities within the wintering area in 9 of 10 attempts. The snowmobile trail alone was the least effective inducement and a combination of snowmobile trails, cedar foliage, and chain-saw noise was the most effective. Some deer traveled to a new location within 24 h after beginning each successful test, and for distances of up to 1.9 km.

Deer moved in response to the above inducements in three phases. In the discovery phase, a few deer traveled between food at the new location and at their customary cover. This stimulated other deer to move to and from the new food source. In the second phase, these deer remained near the new food throughout the day, and they bedded nearby. At this time, the deer made their own trail system from the felled trees to nearby cover, which was frequently marginal in quality (compared to what Gill (1957a) described as good shelter for deer in Maine), rather than returning to their former cover. As the supply of cedar foliage dwindled, deer began to feed heavily on hardwood browse in the vicinity. In the third phase, some deer returned to their original location, while some stayed near the cedar cut.

Many of the deer remained in the new location only as long as the felled cedar trees (with an average of about 110 kg of green foliage/tree) provided food; it appeared this occurred because of the unavailability of sufficient palatable natural browse. Food provided deer by commercial logging operations and food available near trail segments L and M only during the 1973–1974 winter (when there was shallow snow) held deer throughout the winter in cover much inferior and unlike that traditionally used; this was true whether food was naturally available or artificially supplied.

These data and other observations suggest that deer can be relocated throughout a winter if the relocation site has enough good browse for the numbers of deer attracted to it and if the deer can get to the browse.

The effectiveness of chain-saw noise alone in attracting deer was demonstrated twice during the winter of 1972–1973, when a chain saw was operated along little-used snowmobile trails for 30 min without felling trees. In both instances, deer used the snowmobile trail heavily for 0.8–1.4 km within 24 h, presumably in search of food. This agrees with numerous reports by loggers of deer attraction to felling of trees with chain saws; the deer appear to relate the saw noise to a new food supply.

Ten snowmobile trails, totaling 9.1 km, were made in the wintering area for improving deer mobility. Deer use of most of these trails was inversely proportional to off-trail travel conditions but the length of the trails and their proximity to major deer bedding areas also affected their use. Snowmobile trails arranged in a grid pattern allowed more uniform use of available browse than did loop, dead end, and open end trail patterns.

Manpower and time limitations prevented the making of more trails; under some conditions only 0.2 km/h could be made by one man. Doan (1970) and Wettersten (1971) reported that some snowmobile clubs in Manitoba and Minnesota make an outing of providing trails for deer use. But the efficiency and cost of providing snowmobile trails for deer use on a large scale has not been determined.

Deer Response to Snowmobiles and People

During the winter of 1972–1973, 214 encounters with deer were recorded; 36 were on snowmobile trails with the observers snowmobiling, 136 off snowmobile trails with the observers snowmobiling, and 78 while the observers were walking in the study area. Corresponding figures for 1973–1974 were 1, 13, and 18 (sum = 32), and for 1974–1975 were 32, 108, and 33 (sum = 141).

Deer encountered on snowmobile trails usually ran away immediately whereas deer met near a snowmobile trail sometimes ran toward us to gain access to the trail for escape.

More deer ran out of sight than stayed during the first two winters, but more deer stayed in sight during the winter of 1974–1975 (Table 2). Most deer ran from sight in December and January of each winter but they tended to remain within sight during February, March, and April (Table 2). These differences in deer escape behavior may have been associated with a progressive weakening of their physical condition over the course of the winter, as was noted by Severinghaus (1947) for deer in New York. Silver et al. (1969) and Bateman (1972) reported that deer voluntarily reduced their activity in mid-winter and this reduction may have increased their tendency to stay in sight. But the deer also likely became conditioned to snowmobiles as the winter progressed. Young and Boyce (1971) stated that deer fed artificially in Michigan learned to live with snowmobiles, and were conditioned to appear at the sound of them in anticipation of food.

More deer encountered by snowmobilers ran than stayed between 0800 and 1359 h, whereas more deer stayed in place from mid-afternoon to sunset (Table 2). More deer ran than stayed when met in open and hardwood cover types (Table 3) but these tendencies were about equal for deer met in mixedwood and softwood cover. Since deer showed a decided tendency to run when approached by a snowmobile in the open, and an increased tendency to stay when approached in softwood stands, the deer's response seemed to depend on its apparent security. Softwood cover allowed deer to observe without obviously exposing themselves, and with considerable lateral concealment they stayed rather than ran; however, deer could not easily hide in open or hardwood cover types so that they tended to run.

In the present study, deer ran or stayed about equally regardless of the number encountered at one time (Table 3). Forty-one percent of encounters were with one deer, 27% with two, 18% with three, and 14% with four or more deer. More deer encountered near deer trails ran than stayed whereas those encountered away from deer trails stayed or ran about equally. More deer observed within 15 m of the snowmobile trail stayed than ran as the snowmobile passed but beyond that distance, more ran than stayed. It is likely, however, that deer near the trail, that were prone to run away did so before they were

TABLE 2—Deer encounters by winter, month, and time of day, Hayden Brook winter areas, 1972–1975. Test of significance: * at 0.05 level and ** at 0.01 level

	Deer-snowmobile encounters[1]			Deer encountered on foot		
	No. ran	No. stayed	χ^2	No. ran	No. stayed	χ^2
Deer encounters by winter						
1972–1973	99	37	28.3**	70	8	49.3**
1973–1974	9	4	1.9	16	2	10.9**
1974–1975	42	66	5.3*	28	5	16.0**
All years	150	107	7.2**	114	15	76.0**
Deer encounters by month (all years)						
Dec	7	0	7.0**	5	0	5.0*
Jan	46	10	23.1**	8	0	8.0**
Feb	52	35	3.3	46	6	30.8**
Mar	43	51	0.7	46	9	24.9**
Apr	2	11	6.2*	9	0	9.0**
Totals	150	107	7.2	114	15	76.0**
Deer encounters by time of day (all years)						
0800–0959	19	8	4.5*	0	0	
1000–1159	39	19	6.9**	12	0	12.0**
1200–1359	76	45	7.9**	43	13	16.1**
1400–1559	14	32	7.0**	44	1	41.1**
1600–1759	2	9	4.4*	15	1	12.2**
Totals	150	107	7.2	114	15	76.0**

[1]Off snowmobile trails.

TABLE 3—Deer encounters by cover type, group size, and proximity to deer trails, Hayden Brook wintering area, 1972–1975. Test of significance: * at 0.05 level and ** at 0.01 level

	Deer-snowmobile encounters[1]			Deer encountered on foot		
Cover type	No. ran	No. stayed	χ^2	No. ran	No. stayed	χ^2
Deer encounters by cover type (all years)						
Softwood	73	72	0.0	49	8	29.5**
Mixedwood	14	22	1.8	22	1	19.2**
Hardwood	15	6	3.9*	10	1	7.4**
Open	48	7	30.6**	25	5	13.3**
Totals	150	107	7.2**	106	15	68.4**
Deer/Group Deer encounters by group size (all years)						
1	21	23	0.1	33	4	22.7**
2	15	14	0.0	16	2	10.9**
3	11	8	0.5	10	0	10.0**
4+	11	4	3.3	4	1	1.8
Totals	58	49	0.8	63	7	44.8**
Deer encounters in relation to deer trails						
Near deer trails	90	62	5.1**	56	9	34.0**
Away from deer trails	60	45	2.1	58	6	42.2**
Totals	150	107	7.2	114	15	76.0**

[1]Off snowmobile trails.

TABLE 4—Deer encounters by snow depth, and deer sinking depth in open habitats, Hayden Brook wintering area, 1972–1975. Test of significance: * at 0.05 level and ** at 0.01 level

	Deer-snowmobile encounters[1]			Deer encountered on foot		
Snow depth class (cm)	No. ran	No. stayed	χ^2	No. ran	No. stayed	χ^2
Deer encounters by snow depth (all years)						
0 – 15.3 >	0	0	—	3	0	3.0
17.9– 30.5	0	0	—	11	0	11.0**
33.2– 45.9	15	5	5.0*	4	2	0.7
48.5– 61.2	9	3	3.0*	26	2	20.6**
63.8– 76.5	47	14	17.8**	5	2	1.3
79.1– 91.8	37	26	1.9	4	2	0.7
94.4–107.1	37	56	3.1	60	7	41.9**
109.7–122.4	5	3	0.5	1	0	1.0
Totals	150	107	7.2	114	15	76.0**
Deer encounters by sinking depth (all years) Sinking depth (cm)						
0 –10.2 >	39	10	17.2**	42	6	27.0**
12.8–20.4	30	11	8.8*	9	0	9.0**
23.0–30.5	31	29	0.1	37	4	26.6**
33.2–40.8	23	32	1.5	3	0	3.0
43.4–51.0	5	11	2.2	0	0	—
53.6–61.2	0	8	8.0**	0	0	—
63.8–71.4	22	6	9.1**	0	0	—
Totals	150	107	7.2	91	10	64.9**

[1]Off snowmobile trails.

seen. It is also likely that moving deer were more readily seen beyond 15 m than were stationary ones.

When snow depth exceeded 92 cm more deer stayed than ran ($P < 0.01$) when encountered off snowmobile trails (Table 4). At lesser snow depths the opposite response was noted. Deer had a greater tendency to run when they sank into the snow less than 20 cm but they stayed as often as they ran at greater sinking depths.

In this wintering area, deer had access to numerous localities which were inaccessible to snowmobiles because of topography, stand density, or lack of roads. Thus, a deer had to run only a short distance to escape and these inaccessible localities served as refuges. Kopischke (1972) also reported that deer in Minnesota sought places which were inaccessible to snowmobilers during high-use periods.

Some differences in the behavior of deer were related to snowmobiling habits. Snowmobiling at high speeds frightened deer more easily than at low speeds (16 km/h or less), but stopping to view deer invariably resulted in their flight. Also, more deer ran when approached directly than when approached obliquely with a snowmobile, and deer were more easily frightened when observed by looking directly at them than when not.

The reaction of deer to a man walking differed markedly from their reaction to a man on a snowmobile. A significantly greater number of them ran than stayed under all snow, weather, habitat, and temporal conditions recorded during the study (Tables 2, 3, 4). This decided tendency of deer to run with the approach of a human on foot, in contrast to their tendency to stay in sight when approached by a snowmobiler, suggests that the deer responded to the machine and not to the person riding it.

Deer Management Implications

Numbers and total use of snowmobiles will probably continue to increase in the snowbelt of North America. Despite establishment of public trails for snowmobiling (Armstrong 1973),

snowmobiling will likely increase where deer habitually winter. Whether this becomes advantageous or adverse to deer welfare, however, depends on how these machines are used.

It appears that snowmobiles can be used to benefit White-tailed Deer by (1) easing their travel effort in snow, (2) providing trails in nearby brushy areas and large clearings having palatable food, and (3) inducing winter deer movement to suitable and unexploited localities within a wintering area. Such use of the snowmobile seems logical since the major problem of wintering deer on snowy ranges is that of moving to new food sources. This specifically refers to palatable browse above the snow surface but within reaching distance of deer standing in or on the snow.

There is some evidence (from this and other studies), moreover, that deer habituate to judicious use of snowmobiles and we suggest that "taking deer to the forage" may be more profitable in emergency-type management measures than the "taking the forage to the deer" approach of the past. We recognize, however, that additional experimentation is needed to determine the utility or even feasibility of actively using snowmobiles as a deer management tool.

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Winter Movements and Home Range of the Muskrat[1]

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MacArthur, Robert A. 1978. Winter movements and home range of the Muskrat. Canadian Field-Naturalist 92(4): 345–349.

Movements and home range of the Muskrat (*Ondatra zibethicus*) in winter were evaluated from radiotracking studies and the distribution patterns of resting and feeding shelters. Fifty percent or more of all position determinations for each of 11 transmitter-tagged Muskrats were made within 15 m of its primary dwelling lodge. Few movements exceeded 150 m. Most foraging occurred within a 5- to 10-m radius of a lodge or push-up. At one intensively studied site, a reduction in foraging range was observed as winter advanced. Maximal utilization of peripheral home range in early winter may be adaptive in a Muskrat population occupying shallow-water habitat that is subject to extensive freezing during late winter.

Key Words: Muskrats, winter home range, foraging movements, radiotracking.

To date, a substantial quantity of mark and recapture data has been gathered for the Muskrat (*Ondatra zibethicus*) indicating that movements within the summer home range seldom exceed 180 m (Takos 1944; Beshears and Haugen 1953; Wragg 1955; Sather 1958). Based on recoveries of animals tagged in late summer or fall, it appears that Muskrats in winter seldom move beyond the home range established during the period of open water (Aldous 1946; Fuller 1951; Stevens 1953; Sather 1958). Unfortunately, most of these data have been obtained from fur harvests, and difficulties in live-trapping after freeze-up have precluded the accurate delineation of winter home range in this species.

This paper provides insight into the movements and home range of the Muskrat in winter based on radiotracking studies and on the distribution patterns of winter shelters. The data reported herein were gathered while we were conducting field investigations of the microclimate and daily activity and body temperature patterns of the Muskrat during winter (MacArthur 1977).

Methods

All observations were made in Delta Marsh, Manitoba (50°11′N, 98°23′W), between 2 December and 24 February 1973–1974, and between 6 November and 4 January 1974–1975. Data were gathered from six different sites (I to VI) in the western region of the marsh. The topography and vegetation of the area have been described in detail by Olsen (1959) and Walker (1965).

Winter shelter definitions followed Dozier (1948). Accordingly, the term "push-up" designates only those structures consisting of plugs or domes of frozen submergent vegetation overlying open cracks or plunge holes in the ice. Push-ups are constructed after the formation of a persistent ice cover and are supported wholly by the ice. The larger dome- or conical-shaped lodges are composed principally of emergent vegetation and are constructed prior to freeze-up.

Radiotracking studies were conducted on 11 subadult and adult Muskrats (three females, eight males) ranging in body weight from 625 to 941 g. Trapping was done with National Live Traps (16.5 × 16.5 × 48.3 cm) baited with apple and carrot. Animals were trapped mainly at push-ups in November 1973, and on the sides of lodges in October 1974.

Within 12 h of capture, each animal was equipped with an intra-abdominal FM transmitter (Wang 1972) while under Nembutal anaesthesia (30 mg/kg body weight), and was released at the site of capture not later than 24 h after surgery. The continuous tone emitted by each transmitter was received on the FM band of a transistor radio (Sony AM/FM Cassette-

[1]Publication Number 54 in the University of Manitoba Field Station series.

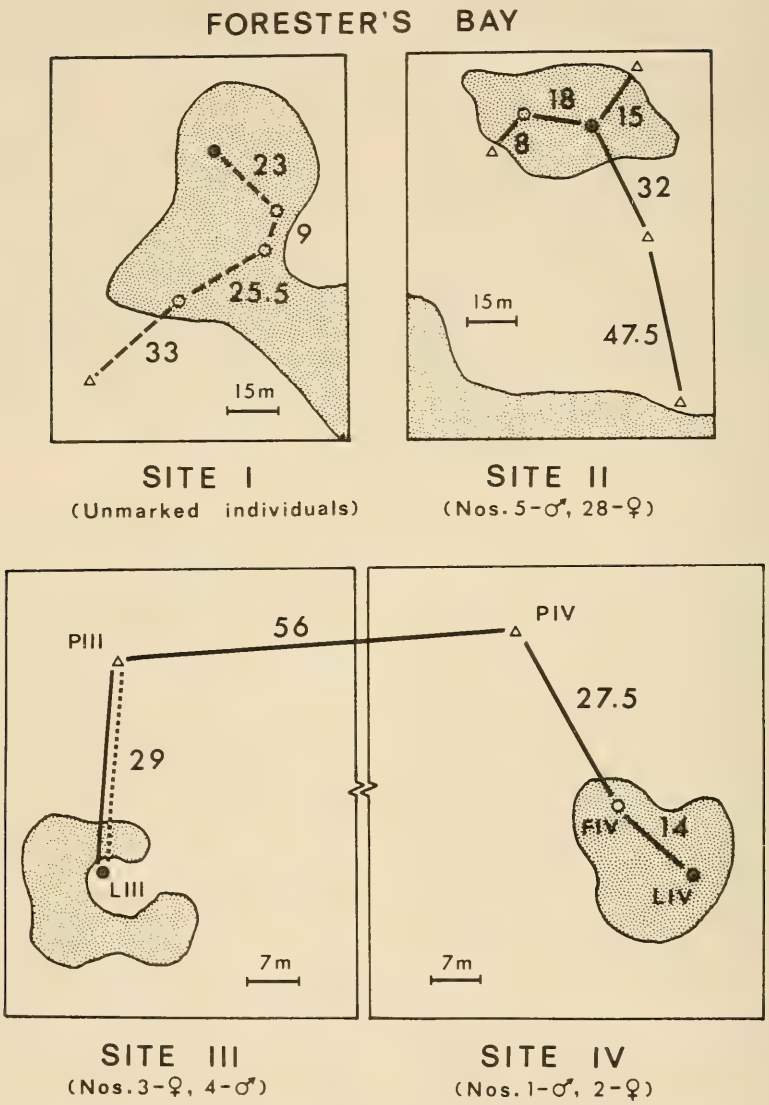

FIGURE 1. Distribution patterns of winter shelters used by Muskrats, *Ondatra zibethicus*, in Forester's Bay, Delta Marsh, Manitoba. Sites II through IV denote home ranges of transmitter-tagged animals, identified in parentheses. Inter-shelter distances are given in meters. Routes verified by radiotracking are indicated for residents of Sites II and IV (—) and Site III (. . .); dashed line at Site I is a potential route only. Stippling indicates emergent stands of bulrush, *Scirpus* spp.; •, dwelling lodges; ○, feeders; △, push-ups.

Recorder, Model CF-350) at a specific frequency that identified an individual animal. The positions of transmitter-tagged Muskrats were censused at periodic intervals (15 to 240 min) throughout the day and night. The low range of the transmitter (15.5 to 30.5 m in air), coupled with careful lateral movements about the point of maximum signal strength, permitted detection of a stationary Muskrat to within approximately ± 2.0 m. Swimming and diving activity resulted in a distinctive rhythmic signal, which aided in behavior evaluation.

All distances indicated in the present study were paced off (estimated accuracy = ± 4%). Daily maximum–minimum air temperatures were available from the University of Manitoba

Field Station located within 2.5 km of all study sites. Lodge ambient temperature was recorded automatically at hourly intervals with a Grant Miniature Temperature Recorder equipped with Type C (small) thermistor probes (Grant Instruments Ltd., Cambridge, England). For lodge instrumentation, thermistor probes were encased in copper tubing (0.6 cm diameter) and inserted through the lodge wall until they protruded 3 to 7 cm inside the nest chamber.

Results

Based on 870 observations of 11 Muskrats, 50% or more of all position determinations for each animal were made within 15 m of its major dwelling lodge. For 10 of the 11 animals, the maximum under-ice distance travelled from a dwelling lodge was less than 150 m. The exceptional individual (Number 5) traversed 366 m in early December 1973, when it abandoned the lodge at which it was trapped and relocated in a neighboring lodge complex. Once relocated, the movements of this animal were comparable to those of the other individuals studied.

Most foraging activity occurred within a 5- to 10-m radius of a lodge or push-up. Feeding lodges (feeders) and push-ups were often distributed about a dwelling lodge in a "stepping-stone" pattern (Figures 1 and 2), and Muskrats usually traversed intervening distances (especially between lodges and push-ups) quickly, via direct routes. In contrast, animals travelling beneath the ice through stands of emergent vegetation often moved slowly, stopping intermittently.

During early winter, there was also evidence of inter-group sharing of push-ups, and in one case, of dwelling lodges. Two of the four animals monitored at Site VI during November and December 1974, for example, were occasionally observed utilizing a push-up associated with Site V (Figure 2). There was no evidence of inter-group sharing of any other shelters by animals from Sites V and VI.

At Sites III and IV, on the other hand, two of the four transmitter-tagged Muskrats (Numbers 1 and 2) utilized dwelling lodges LIII and LIV, and push-ups PIII and PIV during the period 2–15 December 1973 (Figures 1 and 3A). Observed movement between LIII and LIV was always via PIII and PIV, and never directly from

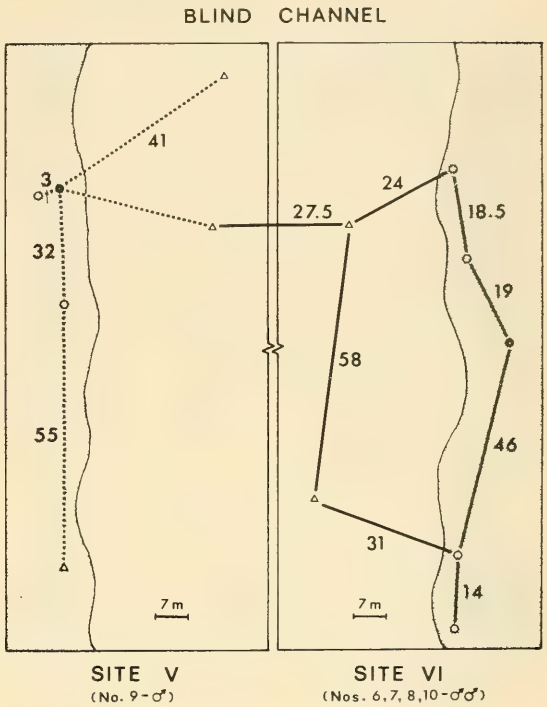

FIGURE 2. Distribution patterns of winter shelters used by Muskrats, *Ondatra zibethicus*, in Blind Channel, Delta Marsh. Routes verified by radiotracking are indicated for residents of Sites V (. . .) and VI (—). Stippling indicates emergent stands of cattail, *Typha latifolia*; all other symbols as in Figure 1.

one lodge to the other (a distance of 78.6 m). By 11 January, PIV had frozen out, and for the remainder of the winter, Muskrats Numbers 1 and 2 were confined to "Island IV" with its single dwelling lodge and associated feeder (Figure 3A). As push-up use by these animals declined, feeder use increased. Push-up PIII remained in use throughout the winter, and the two Muskrats (Numbers 3 and 4) monitored at Site III continued to use this push-up, although here also, there was some indication of decreased push-up, and increased lodge utilization in late winter (Figure 3B). Increase in lodge use at Sites III and IV (especially Site IV) during January and February is also reflected in slight, but significant (Student's t-test, $P < 0.05$) increases in lodge temperature, which occurred despite declining air temperature (Figure 3C).

Discussion

As in summer (Beshears and Haugen 1953;

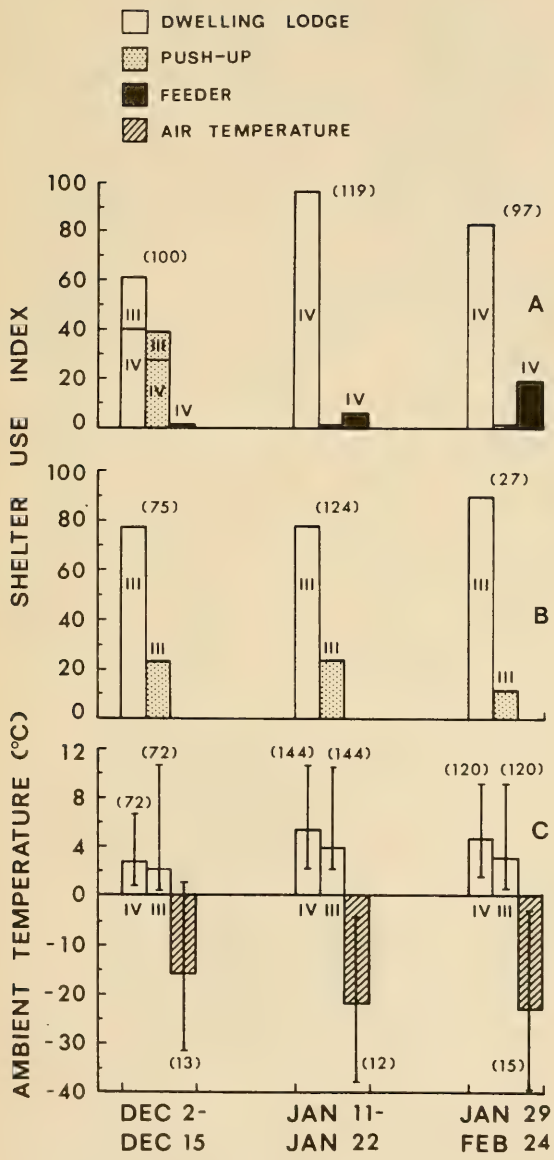

FIGURE 3. Changes in shelter use by Muskrats, *Ondatra zibethicus*, during winter at Sites III and IV, as determined from radiotracking observations of Muskrats Numbers 1 and 2 (A) and Numbers 3 and 4 (B), as well as from variation in mean hourly lodge temperature (C). Sample sizes are given in parentheses; vertical lines denote ranges. Shelter Use Index = (total observations in shelter/total of all observations) × 100.

Wragg 1955; Sather 1958), the winter home range of the Muskrat is restricted, with few movements exceeding 150 m, and most foraging activity focused within a 10-m radius of a lodge or push-up. Moreover, calculation of cumulative, linear distances between adjacent shelters depicted in Figures 1 and 2 (90 to 128 m) probably provides a fairly realistic estimate of the breadth of winter home range in this species. The rapid swimming often observed between lodge and push-up, as opposed to the slower movements along zones of emergent vegetation is attributed to the prevalence of under-ice air spaces in the latter areas.

It must be emphasized that the delineation of each of the six sites (Figures 1 and 2) into separate groups is somewhat arbitrary, and nothing is known concerning possible kinship relationships between animals occupying adjacent sites. It is generally believed that a female overwinters with her last litter of young, possibly in association with one or more adult males (Errington 1963). It has also been observed that first-litter young often establish themselves within 90 m of the female's home range (Errington 1963). Therefore, it is entirely possible that kinship ties existed between as well as within neighboring study sites.

The limited evidence indicating inter-group sharing of push-ups, and in one case, lodges in early winter (Figures 1, 2, and 3A), as well as the trend for maximal push-up use during this period (MacArthur 1977), may have important ecological implications. First, inter-group utilization of shelters would enhance microclimate temperatures within these structures, and in the case of push-ups especially, would inhibit ice formation in plunge holes. Second, water levels in Delta Marsh are characteristically shallow (Walker 1965), and in the past, freezing of the marsh bottom has been considered a major source of winter mortality in this region (Errington 1963). In the two winters during which the present study was conducted, frost had penetrated to the bottom of shallow portions of the marsh by late January and early February. There would therefore seem to be strong selective pressure for maximal utilization of peripheral food resources early in the winter when these are most accessible. Such behavior would conserve food reserves in the immediate vicinity of the dwelling lodge until late winter when they would be essential to sustain the animals in the event that ice impeded

access to distant push-ups. The view is commonly held that Muskrats can survive extensive freezing of their habitat only if they have access to such reserves in proximity to a lodge or burrow (Hamerstrom and Blake 1939; Errington 1963; Revin 1975).

It is also relevant to note that the net energy gain resulting from foraging at distant push-ups would probably decrease as winter advances. Included in the energy expenditure of such activity is the thermoregulatory cost of preparing for, enduring, and recovering from immersion in near-freezing water (MacArthur 1977), as well as the locomotor energy required to reach and forage in the vicinity of the push-up. As winter advances, cooler lodge, push-up, and water temperatures would tend to elevate thermoregulatory costs. In addition, the animals may have to break through surface ice in the push-up plunge hole in severe weather. As food reserves in the immediate vicinity of the push-up are depleted, the foraging range about the latter must also be increased. All of these added costs for distant foraging in late winter might favor a progressive reduction in foraging radius, as observed in the present study.

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Spiranthes lacera var. *lacera* × *S. romanzoffiana*, a New Natural Hybrid Orchid from Ontario

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Simpson, R. C. and P. M. Catling. 1978. *Spiranthes lacera* var. *lacera* × *S. romanzoffiana*, a new natural hybrid orchid from Ontario. Canadian Field-Naturalist 92(4): 350–358.

Plants representing hybrids between the orchids *Spiranthes lacera* var. *lacera* and *S. romanzoffiana* were found in an abandoned sand pit in Killbear Provincial Park, Parry Sound District, Ontario. This hybrid has not been previously reported. The unusual occurrence of the parental species in close contact in the 17-yr-old pit is attributed to variation in soil conditions over short distances and the successional nature of the site. The flower color of the hybrid resembles that of *S. lacera* but the green on the floor of the lip is paler and the green at the base of the perianth parts is more extensive as in *S. romanzoffiana*. The hybrid flowered in mid-July with *S. romanzoffiana* and *S. lacera*, and did not overlap with the August and September flowering time of *S. casei* and *S. cernua*. Although the hybrid possesses certain features unique to either one or the other of its parents, it is intermediate in most respects. Principal components analysis of the four *Spiranthes* species in Killbear Park produced four species clusters, and the hybrid is positioned between the clusters representing *S. lacera* var. *lacera* and *S. romanzoffiana*. A weighted character combination derived from reference samples of the parents by stepwise discriminant function analysis gave the hybrid an intermediate score. Hybrid pollen was highly irregular, with groupings of 1–6. Normal tetrads made up only 49% of pollen examined.

Key Words: *Spiranthes*, hybrid, orchid, Ontario, Canada, numerical taxonomy, pollen.

Several hybrids have been reported in the northeastern North American *Spiranthes* orchids. Ames named certain hybrids from southeastern Massachusetts, but later placed them in synonymy under *S. vernalis* (Ames 1924) which he then viewed as a hybrid complex. Case (1964) and later Voss (1972) thought it likely that plants referable to *S. vernalis* in Michigan were hybrids involving S. *cernua* and *S. lacera* var. *lacera*, but later these northern plants previously referred to *S. vernalis* were described as the new species *S. casei* (Catling and Cruise 1974). The most frequent and widely accepted hybrid *Spiranthes* in the northeast is *S.* × *steigeri*, apparently involving *S. cernua* and *S. romanzoffiana*. It was first noticed in Merrimack County, New Hampshire (Correll 1941), and later it was also reported from Yarmouth County, Nova Scotia (Correll 1950), Chippewa County, Michigan (Case 1964), and northern Vermont (Luer 1975).

A sheet in the herbarium of the New England Botanical Club (NEBC) collected by H. M. Reynolds on Great Cranberry Island, Mount Desert Island, Hancock County, Maine, 22 August 1916, is labelled *S. gracilis* × *S. romanzoffiana*. The taxon previously called *S. gracilis* in Maine is correctly referred to as *S. lacera* var. *lacera* (Voss 1966). Both specimens on this sheet have the general appearance of *S. lacera* but are unusual in having numerous (up to 11) and relatively long, cauline bracts, and long lower floral bracts (10–12.5 mm). Measurements of all other plant parts including measurements of softened flowers are well within the range of *S. lacera*.

On 15 July 1976, R. C. Simpson discovered three apparent *S. lacera* var. *lacera* × *S. romanzoffiana* hybrids in an old sand pit near the maintenance yard in Killbear Provincial Park, Parry Sound District, Ontario (45°22′N, 80°13′W) (Figure 1). These plants were found in a corner (0.5 ha in area) of the pit that had been dug out 17 yr previously and left undisturbed since then. Alders (*Alnus rugosa*) had colonized much of the area and *S. romanzoffiana* was quite common in the lower parts of the pit in 1976 where it grew in association with *Sphagnum* spp., *Equisetum variegatum, Lycopodium inundatum, Fimbristylis autumnalis, Carex aurea, Eleocharis elliptica, Platanthera clavellata,* and *Liparis loeselii. Spiranthes lacera* var. *lacera* occurred in drier parts of the pit with *Polytrichum* sp., *Lycopodium clavatum* var. *monostachyon, Vaccinium angustifolium,* and *Malaxis unifolia*. The putative hybrids were found with *Polytrichum* sp. at the base of a drier slope.

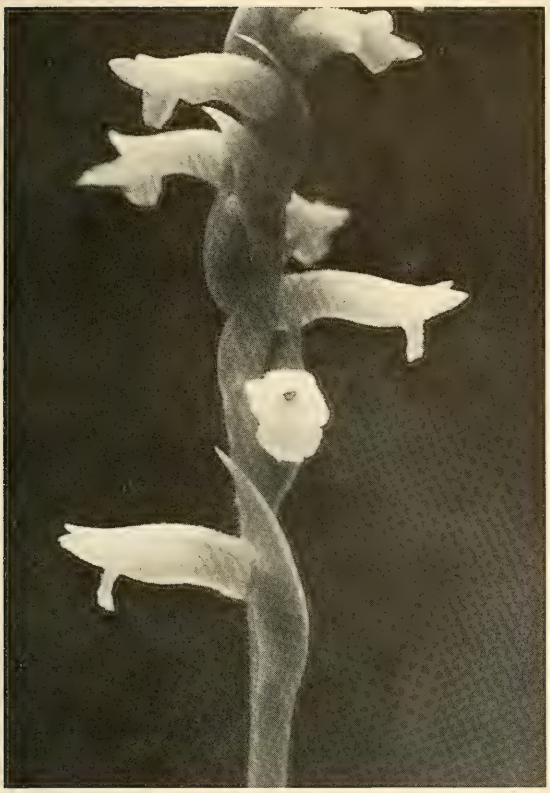

FIGURE 1. *Spiranthes lacera* var. *lacera* × *romanzoffiana* from Killbear Provincial Park, Parry Sound District, Ontario. Photographed 18 July 1977.

The only apparent hybrid found in 1977 was located on a drier slope with *Polytrichum* sp. in the partial shade of *Alnus rugosa* and *Vaccinium angustifolium*. In addition, 30 flowering plants of *S. romanzoffiana* and 11 flowering plants of *S. lacera* var. *lacera* were found. One of the latter was growing among *Sphagnum* spp. in a damp location but the others were in drier places with *Polytrichum* sp. The *S. romanzoffiana* specimens occurred in both moist and dry places and several plants were within a metre of a plant of *S. lacera*. Where *S. romanzoffiana* occurred on drier slopes it was in shaded situations. In Ontario *S. romanzoffiana* is usually found in relatively moist environments, but it is occasionally encountered in places that are only seasonally moist, often becoming quite dry in mid- or late summer. *Spiranthes lacera* var. *lacera* is most often found on dry rocky ridges, in pine or oak woods, and in dry pine plantations. It has been encountered twice in *Sphagnum* bogs in Ontario, but this is a very unusual habitat.

Spiranthes lacera var. *lacera* and *S. romanzoffiana* are rarely found in close contact, but disused sand pits often exhibit a great variety of soil conditions over short distances and the successional nature of the vegetation and the habitat as a whole frequently leads to an unusual diversity and associations that are not commonly encountered elsewhere.

Although the three apparent hybrids found in 1976 appeared intermediate between *S. lacera* var. *lacera* and *S. romanzoffiana*, they differed somewhat from each other. The lateral sepals were connivent forming a hood in one plant resembling *S. romanzoffiana* but another had flaring lateral sepals, more or less separated from the dorsal sepal. This latter plant had essentially white flowers similar to those of *S. lacera* var. *lacera* which are pure white (excepting parts of the lip). In all three plants the floor of the lip was greenish but less intense than is common in *S. lacera* var. *lacera*, and elsewhere the flowers of two plants had the creamy appearance of *S. romanzoffiana*. Although few measurements of the floral parts were made at the time of the initial discovery, those that were made strongly suggested the suspected hybrid origin. Flowers near the base of the inflorescence had lateral sepals 1.9 × 6.9 mm and lips 3.0 × 6.0 mm.

During our 1977 visit to the site various data were collected in an attempt to establish definitely the hybrid nature of the plants in question.

Methods

Both the apparent hybrid and all other *Spiranthes* species occurring in Killbear Provincial Park were examined closely and notes were made on flowering time and on various morphological features. Flower color was determined through reference to the Royal Horticultural Society Colour Chart (1966).

Twenty-eight measurements were made of eight individuals of each of four *Spiranthes* species from Killbear Park. This included *S. lacera*, *S. romanzoffiana*, *S. cernua*, and *S. casei* which are the only species occurring in the Killbear region. Means and standard deviations were calculated for all 28 characters to enable character-by-character comparisons (Table 1).

TABLE 1—Comparison of measurements (means and standard deviations) in millimetres, and floral numbers in eight specimens of each of four species from Killbear Provincial Park, Parry Sound District, Ontario. Putative hybrid data are also shown, ROM = *S. romanzoffiana*, LAC = *S. lacera* var. *lacera*, CER = *S. cernua*, CAS = *S. casei*, H = putative hybrid. Numbers in brackets to the right of characters indicate relatively high loadings on a particular component

Character	Means ± SD for four species				
	H	ROM	LAC	CER	CAS
1 uppermost leaf length (1)	57.0	71.75 ± 13.46	18.25 ± 6.18	99.25 ± 39.90	66.87 ± 15.32
2 uppermost leaf width (2)	13.0	8.13 ± 1.42	8.46 ± 1.29	7.06 ± 0.98	5.94 ± 0.98
3 uppermost cauline bract length	14.0	16.06 ± 3.77	9.27 ± 2.89	17.00 ± 2.67	14.50 ± 2.84
4 inflorescence length	40.0	50.25 ± 21.41	58.87 ± 20.61	51.50 ± 12.14	73.50 ± 22.35
5 flower number	17.0	23.75 ± 9.88	19.87 ± 5.96	20.00 ± 4.34	22.25 ± 6.41
6 lowest floral bract length (1)	9.0	11.91 ± 1.86	6.70 ± 2.28	12.96 ± 1.41	9.87 ± 1.16
7 *separation of dorsal and lateral sepals	0.0	0.00 ± 0.00	1.15 ± 0.11	0.49 ± 0.12	0.77 ± 0.22
8 sepal length (1)	7.0	9.51 ± 0.76	5.30 ± 0.58	10.32 ± 0.78	6.19 ± 0.66
9 sepal width (1)	2.0	3.51 ± 0.50	1.46 ± 0.17	2.55 ± 0.33	2.65 ± 0.27
10 flower width at ½ length (1)	1.8	3.01 ± 0.52	1.54 ± 0.18	2.97 ± 0.37	2.81 ± 0.47
11 petal length (1, 3)	5.7	8.79 ± 0.51	5.20 ± 0.50	10.42 ± 0.53	5.74 ± 0.67
12 petal width (1)	1.3	2.17 ± 0.53	1.16 ± 0.14	2.62 ± 0.32	2.31 ± 0.22
13 dorsal sepal length (1, 3)	6.4	9.11 ± 0.45	5.10 ± 0.56	10.71 ± 0.66	6.05 ± 0.76
14 dorsal sepal width (1)	2.0	3.21 ± 0.53	1.61 ± 0.24	3.25 ± 0.43	2.96 ± 0.35
15 lip length (1, 3)	6.4	8.52 ± 0.56	5.39 ± 0.43	10.15 ± 0.56	6.10 ± 0.67
16 lip width (1)	3.2	4.84 ± 1.11	2.70 ± 0.38	5.17 ± 0.58	4.66 ± 0.60
17 lip distal dilation (2)	0.0	1.31 ± 0.35	0.14 ± 0.21	0.25 ± 0.21	0.00 ± 0.00
18 calli length	0.3	0.55 ± 0.19	0.70 ± 0.11	0.86 ± 0.09	0.96 ± 0.11
19 calli width (3)	0.3	0.47 ± 0.10	0.49 ± 0.12	0.74 ± 0.14	0.75 ± 0.15
20 anther sac length	1.35	1.94 ± 0.22	1.42 ± 0.21	2.46 ± 0.14	2.34 ± 0.12
21 anther sac width	0.45	0.81 ± 0.15	0.41 ± 0.08	0.72 ± 0.09	0.66 ± 0.07
22 stigma length†	0.95	1.01 ± 0.18	0.90 ± 0.12	0.84 ± 0.07	1.12 ± 0.12
23 stigma width (1)	1.30	1.81 ± 0.25	0.91 ± 0.12	1.49 ± 0.15	1.50 ± 0.19
24 column length (1)	3.7	3.90 ± 0.30	2.67 ± 0.23	3.86 ± 0.27	3.44 ± 0.23
25 rostellum length (1)	1.1	1.77 ± 0.14	0.87 ± 0.12	1.50 ± 0.05	1.39 ± 0.06
26 ovary length (1)	4.7	6.41 ± 1.25	3.95 ± 0.72	5.70 ± 0.69	5.44 ± 0.70
27 ovary width	1.6	2.52 ± 0.46	1.39 ± 0.22	2.32 ± 0.27	2.85 ± 0.39
28 lip basal claw length	0.8	0.29 ± 0.06	0.76 ± 0.07	0.45 ± 0.05	0.66 ± 0.09

*Measured at ½ length of the flower in lateral view.

†Measured along the main axis, i.e., parallel to the column.

The numerical taxonomy system of multivariate statistical programs (NT-SYS) written by F. J. Rohlf, J. Kishpaugh, and D. Kirk (1974, State University of New York, Stony Brook) was used to standardize the data and produce a character-by-character correlation matrix which was subjected to a principal components analysis (Sneath and Sokal 1973, pp. 245–247). This procedure does not assume any previous determination of groups. The dimensionality of the data is reduced in a way that allows as much of the relationship of individuals as possible to be illustrated in three dimensions. It was hoped that this analysis would position the four species and the putative hybrid in such a way as to indicate further the likely percentage of the latter. Assuming random character sampling and additive inheritance, the hybrid should occupy a position in between its parents. A perspective program called PHYSETER written by A. R. Gibson (1978, Department of Zoology, University of Toronto) was used with the first three principal components analysis (PCA) coordinates for each specimen to produce various three-dimensional views and "Gould" plots.

In addition to the measurements of *Spiranthes* species within the park, specimens of *S. romanzoffiana* and *S. lacera* var. *lacera* from a number of localities (Table 2) were selected randomly or chosen because they represented apparent extremes in size. Twenty-eight characters were measured on each of 62 specimens of *S. lacera* and 58 of *S. romanzoffiana* (Table 3). Means and standard deviations were calculated to facilitate comparison with the hybrid data (Table 3), and in addition a stepwise

TABLE 2—Location and corresponding numbers of individuals of *S. lacera* var. *lacera* and *S. romanzoffiana* selected for statistical analysis

Locations	Numbers of individuals	
	S. lacera	*S. romanzoffiana*
Killbear Park, Parry Sound Dist.	8	8
Whitchurch Tp., York Co.	15	2
Presqu'ile Park, Northumberland Co.	—	15
Haldimand Tp., Northumberland Co.	5	—
Minesing, Simcoe Co.	7	—
Midhurst, Simcoe Co.	12	—
Hepworth, Bruce Co.	15	—
Parry Sound, Parry Sound Dist.	—	3
Hopkins Bay, Bruce Co.	—	15
Wingfield Basin, Bruce Co.	—	15
Totals	62	58

discriminant function analysis (DFA) was performed.

With the exception of separation of the dorsal and lateral sepals (which is deleted), and plant height (which is added), the characters used in the DFA are the same as those used in PCA. The distance of separation of the sepals is deleted since it was found consistently to have values of 0.0 for *S. romanzoffiana* and values of about 1.0 for *S. lacera*, which would result in a relatively large discriminant weight with the exclusion of other characters. Also it is a feature relating more to the positioning of floral parts than to actual dimensions. Plant height was left out of PCA since it is largely a phenotypic feature characterized by relatively large variation and it was undesirable to overload the PCA with characters relating to overall size. Plant height, however, is of some value in discriminating between *S. romanzoffiana* and *S. lacera* var. *lacera*.

Discriminant functions analysis employs a formula of weighted characters resulting in a single score that maximizes the separation between two or more groups. This technique can be useful in phenetic recognition of hybrids since it illustrates the position of a hybrid with respect to the most powerful means of discriminating the parents (Schueler and Rising 1976). There are certain limitations regarding both statistical and biological assumptions, such as random character sampling, multivariate normality, homogeneous dispersion matrices (i.e., clusters of similar size, shape, and orientation), and hybrid intermediacy. Provided that the assumptions are not seriously invalid, the formula derived from reference samples of parental taxa will give an F_1 hybrid an intermediate discriminant variate score. A stepwise DFA program (BMDP-7M) developed by P. Sampsom (Health Sciences Computing Facility, University of California) was utilized. All programs were run in the University of Toronto IBM/370 Computer. Various data not included here (raw data, eigenvectors) are available at nominal charge from the Depository of Unpublished Data, CISTI, National Resarch Council of Canada, Ottawa, Ontario K1A 0S2.

Fresh pollen was stained using the differential stain technique described by Owczarzak (1952). This technique does not lead to any change in the size of the grains (i.e., no swelling or shrinkage) in the taxa studied here. The cytoplasm is stained purplish-red with the phloxine component and the walls are stained pale green with methyl green. This technique is especially useful in the present case since it determines not only the presence of cytoplasm, but it greatly facilitates counting the number of grains adhering together. Ripened pollinia were placed on a glass slide with two drops of 70% ethanol, which helped to separate the groups (normally tetrads) from one another. After agitation with a needle and addition of ethanol as required to distribute the pollen evenly, a drop of stain and a cover slip were applied. The presence of cytoplasm and the frequency of normal pollen tetrads in an individual plant were then determined by observing the first 200 groupings from five flowers on that individual plant. The results of these observations for an individual plant were then combined to give a mean percent frequency of normal and various types of aberrant pollen.

Results and Discussion

Flower colors of *S. romanzoffiana* at several Ontario localities (see Table 1) were found to be essentially the same. The flowers are an overall very pale yellowish-green (4d, 150 D) with green (144 B–C, 143 C, 145 A) extending over the

TABLE 3—Comparison of measurements (means and standard deviations) and character weights for 28 characters measured in 58 fresh specimens of *S. romanzoffiana*, 62 of *S. lacera* var. *lacera*, and 1 hybrid. ROM = *S. romanzoffiana*, LAC = S. lacera var. *lacera*

Character	Means ± SD for two species		Hybrid data	DFA character weights*
	ROM	LAC		
1 uppermost leaf length	91.03 ± 30.27	29.60 ± 9.10	57.0	—
2 uppermost leaf width	6.03 ± 1.71	12.21 ± 3.60	13.0	−0.10328
3 uppermost cauline bract length	18.58 ± 4.75	10.07 ± 2.47	14.0	—
4 plant height	208.48 ± 62.96	283.13 ± 54.30	220.0	—
5 inflorescence length	49.15 ± 18.15	62.34 ± 18.98	40.0	−0.02261
6 flower number	21.50 ± 8.36	20.69 ± 5.60	17.0	—
7 lowest floral bract length	14.36 ± 3.30	7.39 ± 1.67	9.0	0.14204
8 sepal length	9.75 ± 1.10	5.39 ± 0.56	7.0	—
9 sepal width	3.33 ± 0.51	1.54 ± 0.22	2.0	—
10 flower width at ½ length	2.72 ± 0.42	1.59 ± 0.21	1.8	—
11 petal length	9.08 ± 0.89	5.18 ± 0.45	5.7	—
12 petal width	2.04 ± 0.42	1.12 ± 0.14	1.3	—
13 dorsal sepal length	9.15 ± 0.89	5.00 ± 0.50	6.4	0.80072
14 dorsal sepal width	3.17 ± 0.52	1.63 ± 0.20	2.0	—
15 lip length	8.77 ± 0.85	5.51 ± 0.47	6.4	—
16 lip width	4.52 ± 0.78	2.85 ± 0.39	3.2	—
17 lip distal dilation	1.31 ± 0.48	0.10 ± 0.19	0.0	—
18 calli length	0.61 ± 0.17	0.70 ± 0.12	0.3	—
19 calli width	0.46 ± 0.12	0.51 ± 0.13	0.3	−3.29772
20 anther sac length	1.98 ± 0.36	1.35 ± 0.14	1.35	—
21 anther sac width	0.74 ± 0.13	0.40 ± 0.08	0.45	—
22 stigma length	1.06 ± 0.12	0.89 ± 0.12	0.95	—
23 stigma width	1.61 ± 0.24	0.92 ± 0.13	1.30	—
24 column length	3.99 ± 0.31	2.72 ± 0.25	3.7	2.19607
25 rostellum length	1.72 ± 0.18	0.94 ± 0.08	1.1	2.98439
26 ovary length	6.24 ± 1.11	3.88 ± 0.64	4.7	−0.30825
27 ovary width	2.49 ± 0.45	1.35 ± 0.23	1.6	—
28 lip basal claw length	0.36 ± 0.08	0.84 ± 0.12	0.8	−6.80424

*From the discriminant function subtract the constant 8.91585.

basal 1–2 mm and gradually fading out. The central portion of the lip varied from a yellowish (1 D–3 D) ground color to green (144 D) but veins are always dark green (145 A, 144 A, B, C), and the calli are always white (155 D). The flowers of *S. lacera* var. *lacera* are overall white (155 D) with only a fraction of a millimetre at the base being yellowish-green (144 A–D). The central portion of the lip is deep to pale green (144 B, C, 143 C, 149 A, B) and the calli are pale greenish (144 D). The hybrid found in 1977 had overall whitish (155 D) flowers with yellowish-green (144 A–D) extending for 2 mm from the base. The central portion of the lip was pale greenish (144 C, 145 A) and the calli were very pale greenish (144 D). In overall color the hybrid resembled *S. lacera* but like *S. romanzoffiana* the green was more extensive basally and the green in the central portion of the lip was paler. The pale greenish color of the basal calli is a feature shared exclusively with *S. lacera,* as based on our observations of Ontario *Spiranthes* species.

The hybrids flowered simultaneously with their parents in mid-July, but did not overlap with the earliest flowering plants of *S. cernua* and *S. casei* which flower in August and September. Both of these latter species are without green coloration in the lip. In addition both have much larger basal calli and a conspicuous and dense glandular-capitate pubescence on the axis immediately below the inflorescence, the hairs ranging from 0.4 to 1.4 mm. The hybrid and its parents appear glabrous in this region, but close inspection reveals a sparse glandular pubescence up to 0.2 mm in length. This pubescence, however, is unlike that of *S. cernua* and *S. casei* in both its

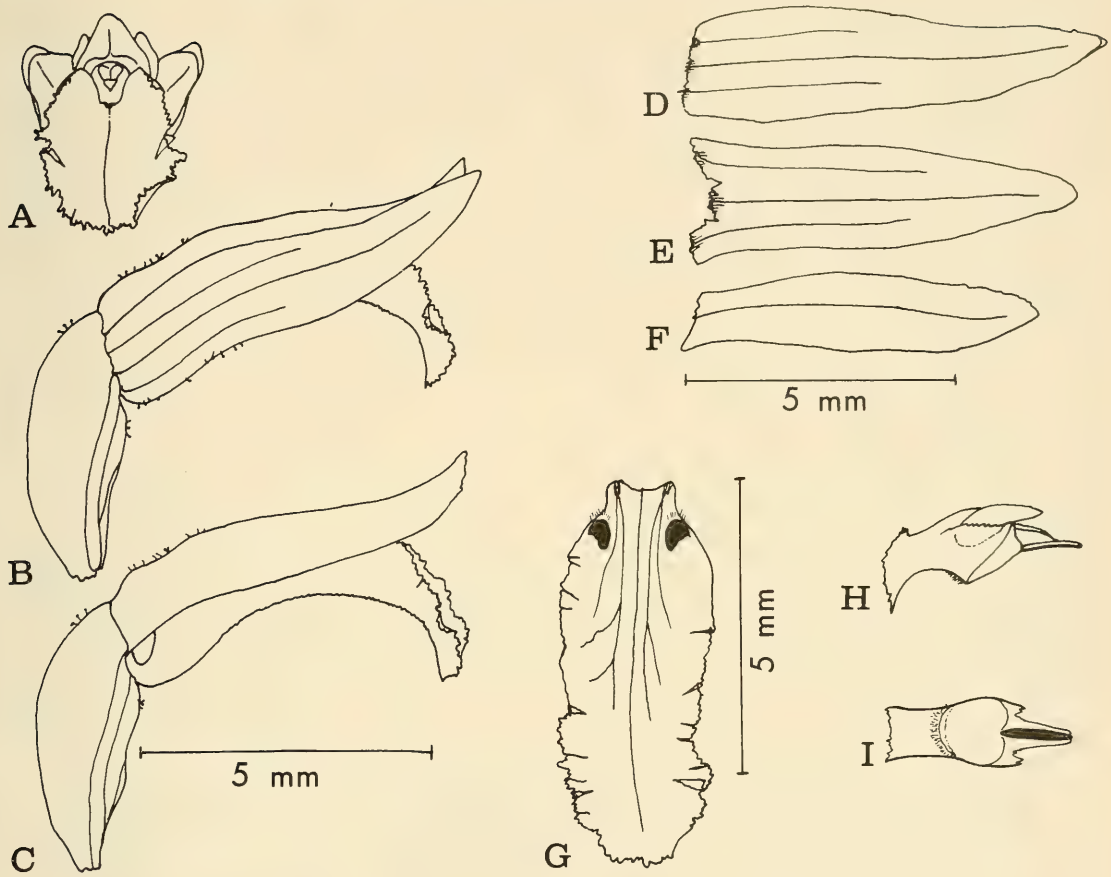

FIGURE 2. Camera lucida drawings of a flower of *S. lacera* var. × *romanzoffiana* from Killbear Park, Ontario. A, flower, frontal aspect; B, flower, lateral aspect; C, flower, lateral aspect, lateral sepal removed; D, lateral sepal; E, dorsal sepal; F, lateral petal; G, lip; H, column, lateral aspect; I, column, ventral aspect.

length and density. The lower flowers of *S. cernua* are almost always longer than the lower flowers of the hybrid and the perianth parts of *S. casei* are considerably wider, although similar in length.

The 1977 hybrid appeared intermediate between the parents in many respects, but had some characters unique to one or the other parent (i.e., not possessed by the other local species of *Spiranthes*). The relatively small basal calli, the prominent veins on the appressed lateral sepals, and the tendency for the lateral and dorsal sepals to be connivent, are features unique to *S. romanzoffiana* (Figure 2). The relatively narrow perianth parts, the gradually tapering base of the lip and the relatively long claw of the lip are features unique to *S. lacera* var. *lacera*. Characters with values intermediate between *S. lacera* and *S. romanzoffiana* include leaf length, bract lengths, lengths and widths of various perianth parts, ovary length and width, and various measurements of parts of the column (see Table 1). In addition, the sepals (both dorsal and lateral) of the hybrid are adnate basally for 0.4–0.5 mm. *Spiranthes romanzoffiana* is characterized by 1.0–2.0 mm of basal adnation while *S. lacera* as well as *S. cernua* and *S. casei* normally have less than 0.3 mm of basal adnation.

The principal components analysis (Figure 3) produced four clusters corresponding to the four species found in Killbear Park. The first component accounting for 56.8% of the variation separates *S. lacera* from *S. casei* and

both of these from *S. romanzoffiana* and *S. cernua*. The second component representing 14.9% of the variation separates *S. casei* from the other three and *S. romanzoffiana* partially from *S. cernua*. The third component accounting for 9.2% of variation separates *S. cernua* and *S. romanzoffiana*. Since 81.0% of the variation is explained by the first three components, the PCA illustration can be considered a reliable representation. The hybrid is positioned between the clusters representing *S. lacera* and *S. romanzoffiana*.

Component 1 reflects differences between species in leaf length, bract length, and several features relating to flower size. Component 2 is characterized by a relatively heavy loading for leaf width and distal dilation of the lip which reflects lip shape. The third component concerns the size of various floral parts. Those characters with loadings above 0.80 for component 1, above 0.40 for component 2, and above 0.30 for component 3 are shown in Table 1.

Comparison of the hybrid with a larger sample of its parents representing a wider geographical area (Tables 2 and 3) further establishes its intermediacy, and confirms certain conclusions based on the smaller sample from Killbear Park alone (Table 1). The flowers of the hybrid varied very little except in overall size, those higher up the spike being smaller as is normal in *Spiranthes*. The only other variation observed related to the distal dilation of the lip. Two of several flowers from the hybrid plant exhibited a tendency to be wider distally beyond a narrower neck, and even here the dilation was relatively slight. The dilation of the hybrid lip shown in Figure 2G is 0.4 mm.

The stepwise discriminant function analysis selected 9 of the original 28 characters (Table 3), and gave an impressive separation of the reference samples of *S. lacera* var. *lacera* and *S. romanzoffiana* (Figure 4). Using the weighted character combinations derived from these reference samples (Table 2) on the hybrid data, an intermediate discriminant variate score was obtained, placing the hybrid beyond the 98% confidence limits of scores of either parent and further supporting a hybrid origin.

Using the nine weighted variables (see Table 3) it should be possible to identify any suspected F_1

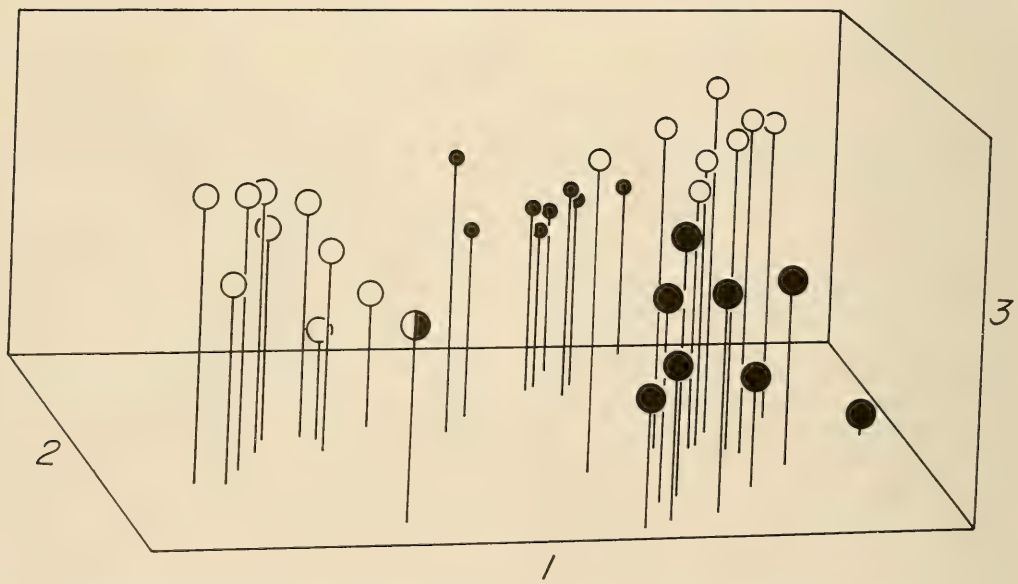

FIGURE 3. A principal components diagram based on correlations among 28 characters. Component 1, 2, and 3 account for 56.8, 14.9, and 9.2% of the variation respectively. Larger darkened circles = *S. romanzoffiana*, smaller darkened circles = *S. casei*, open circles to left = *S. lacera* var. *lacera*, open circles to right = *S. cernua*. The putative hybrid (semi-darkened circle) occupies a space in between *S. lacera* var. *lacera* and *S. romanzoffiana*.

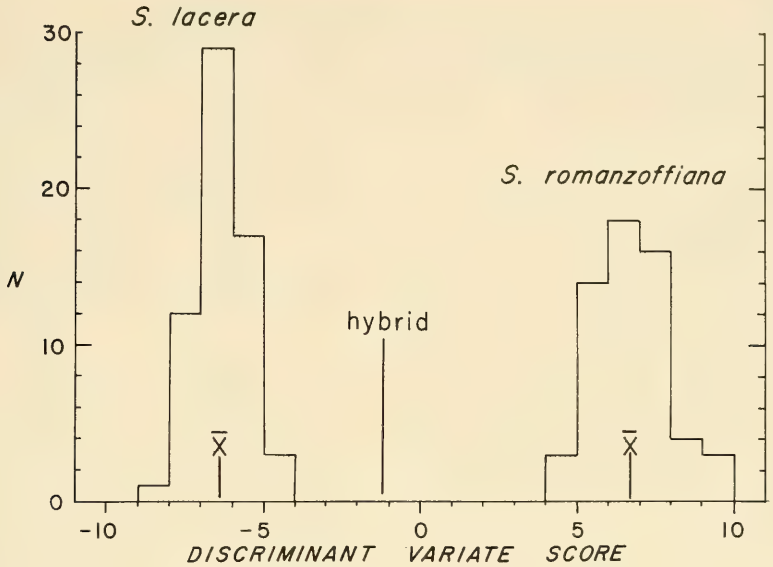

FIGURE 4. Histograms of discriminant scores of 58 specimens of *S. romanzoffiana* and 62 of *S. lacera* var. *lacera*, representing a wide area of southern Ontario (including Killbear Park) with no more than 15 specimens of either taxon from any one locality. The plot is based on the "best" discriminant function incorporating 9 floral characters derived in stepwise fashion from 28 (see Table 1). The position of the hybrid (DFA score −1.23) is indicated. For *S. romanzoffiana* the group mean ($\bar{x}$) is 6.76 and the standard deviation of scores is 1.16. For *S. lacera* the group mean ($\bar{x}$) is −6.32 and the standard deviation is 0.82.

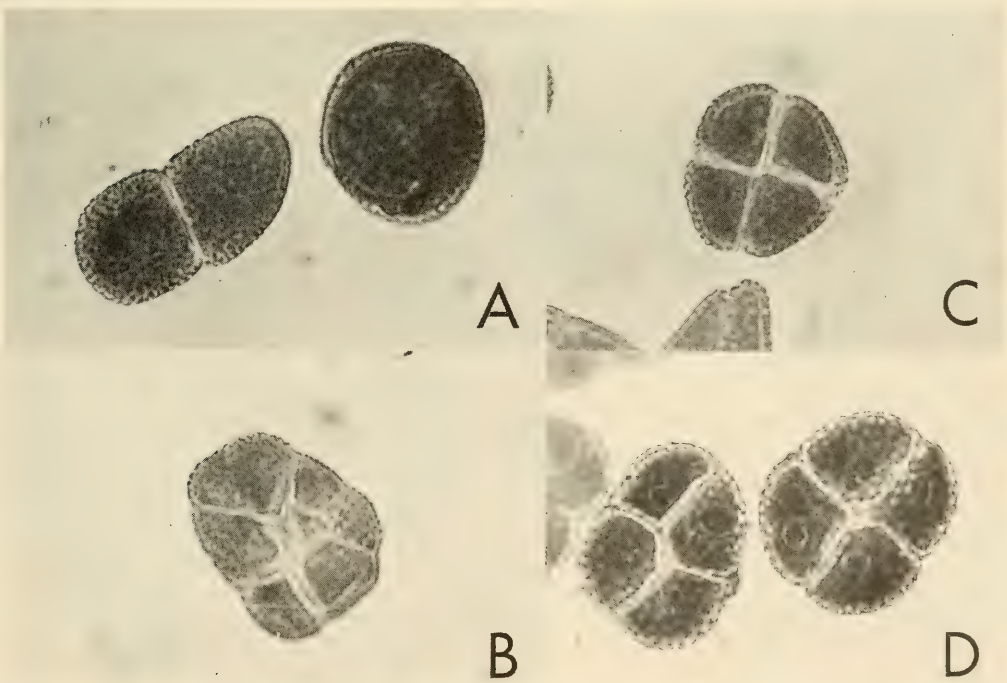

FIGURE 5. Pollen of *Spiranthes*. A, *S. lacera* × *romanzoffiana*, dyad 24.0 × 48.0 μm and monad 35.2 × 36.8 μm; B, *S. lacera* × *romanzoffiana*, a group of 6, 35.2 × 44.8 μm; C, *S. lacera*, tetrad 30.4 × 35.2 μm; D, *S. romanzoffiana*, larger tetrad 38.4 × 44.8 μm.

hybrids. Although the reference samples used here are derived exclusively from Ontario populations of *S. lacera* var. *lacera* and *S. romanzoffiana*, these taxa appear to vary relatively little throughout their North American range. One of the two specimens labelled as *S. lacera* × *S. romanzoffiana* at NEBC (see above) was complete enough to be determined by the discriminant function. It had a discriminant variate score of –5.06, placing it with *S. lacera* and confirming the results of previous examination. Detailed notes have been appended to this sheet.

In northeastern species of *Spiranthes* the pollen grains normally occur in tightly bound tetrads which are mostly tetragonal but also frequently rhomboidal or linear. Hybrids may be expected to produce sterile pollen with a relatively high incidence of irregular groupings of grains compared with the frequency of normal tetrads. Kallunki (1976) has recently associated a relatively high percentage of abnormal pollen (comprised of tetrads with additional micropollen grains as well as dyads and triads) with hybrids involving *Goodyera tesselata*.

Five plants of each of the putative parents at the Killbear sand pit revealed 100% normal pollen, and similarly plants of *S. lacera* var. *lacera* and *S. romanzoffiana* from several other locations in Ontario revealed 99–100% normal pollen. The hybrid plant revealed only 48.6% normal tetrads, monads represented 15.8%, dyads 19.1%, triads 14.2%, and groups of five and six accounted for 2.2% (Figure 5). In all cases including both putative parents and the hybrid plant, the cytoplasm stained well. A large portion of the abnormal hybrid pollen, however, presumably had unbalanced chromosome complements and would be sterile.

No significant differences in the size of pollen has been found between *S. lacera* var. *lacera* and *S. romanzoffiana* in Ontario, and the normal grains of the hybrid were well within the range of size variation of the parents.

Dried material and photographs of the *S. lacera* var. *lacera* × *S. romanzoffiana* hybrid have been deposited in AMES, CAN, and TRT.

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Comparison of Pollen Collected by a Honey Bee Colony with a Modern Wind-dispersed Pollen Assemblage

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Adams, Reg J., G. Christine Manville, and John H. McAndrews. 1978. Comparison of pollen collected by a Honey Bee colony with a modern wind-dispersed pollen assemblage. Canadian Field-Naturalist 92(4): 359–368.

Forty-six pollen types found during 1976 in Honey Bee (*Apis mellifera*) pellets from a single hive in southern Ontario showed a seasonal pattern related to pollen availability. Honey Bees collected pollen from both native and introduced plants. They concentrated on anemophilous (wind-pollinated) forest trees, entomophilous (insect pollinated) fruit trees and early-blooming entomophilous herbs in the spring; later in the season they collected from entomophilous forage crops, weeds, and shrubs that grow in disturbed habitats. The pollen assemblage from lake mud was dominated by anemophilous taxa. This assemblage is compared to the local pollen present in bee pellets.

Key Words: pollen, Honey Bees, Ontario, season, entomophily, anemophily, pollen rain.

Honey Bees (*Apis mellifera*) collect pollen as a source of protein for raising broods and to supplement a diet of nectar and honey (Free 1970; Stanley and Linskens 1974). While collecting pollen, Honey Bees pollinate many agricultural crops. They have been associated with agriculture for at least the past 2300 years (Geroulanos 1973) and were introduced into southern Ontario by late 18th or early 19th century settlers (Jones 1946), who also introduced fruit trees, vegetables, forage crops, and weeds (Ontario Agricultural Commission 1881).

In both Europe and North America, general knowledge of insect pollination (entomophily) is enhanced by the study of pollen collection by Honey Bees (Maurizio 1949; Maurizio and Louveaux 1967; Synge 1947; Lieux 1972, 1975; McLellan 1976) and by solitary bees (Heinrich 1976).

We provide here illustrations of pollen collected by Honey Bees in southern Ontario as an aid to future study and we document the seasonal trends of pollen collection observed during 1976. The number of taxa and the percentage of each taxon are compared with the surface pollen assemblage of a nearby lake. To our knowledge, this is the first documentation of seasonal Honey Bee pollen collection in southern Ontario and the first quantitative comparison of Honey Bee collection and the atmospheric pollen rain from a specific area. This comparison requires the distinction between dispersal mechanisms and floral adaptations such as anemophily (wind pollination) and entomophily (Faegri and van der Pijl 1971), since floral adaptation does not limit pollen dispersal to only one vector such as wind or insects.

Methods

The study hive was located in the Campbell Bee Yard near Brantford, Ontario at 43°10′N, 80°18′W. Brantford is located in the deciduous forest region (Rowe 1972). The size of a Honey Bee foraging area (Free 1970) is within 1.6 km (1 mi) of the colony. Present land use in the study area is about 75% pasture and cultivated land and 5 to 10% woodlands; 15 to 20% of the area is taken up by urban development and roads (Canada Surveys and Mapping Branch 1974). These percentages are unlikely to have changed appreciably between the date of the survey and that of our study.

Pollen pellet samples were taken from the colony with a pollen trap consisting of a cloth pellet-collecting tray at the base of the trap, two layers of screening with four openings in 2 cm (five meshes per in.) above the tray and a single upper layer of screening with five openings in 2 cm (six to seven meshes per in.). The upper screen removed pellets from the corbiculae or

pollen baskets on the bee's rear legs. The lower two layers prevent complete pellet retrieval by the bees, although they are still able to carry 20 to 30% of the pellets into the hive. The entire trap is installed between the standard floorboard of the hive and the upper portion (supers) of the hive so that the trap entrance replaces the original hive entrance (Smith and Adie 1963). The trap was used for one day each week and then removed to allow the bees unimpeded access to the hive. Trapping began 18 April and ended 1 October. Although the bees may have collected pollen before and after these dates, this period is the major collection time. In mid-season at the peak of the pollen flow as much as 500 g of pollen may be collected by one bee colony (Smith and Adie 1963).

Variation in pellet color, size (from 1 to 4 mm diameter), shape, and texture have previously been used to determine the pollen types present and their percentages (Synge 1947; McLellan 1976). We used an alternate method to ensure a representative sample of each day's pellet collection by dispersing a 50-mL pellet sample in 350 mL of water with frequent stirring. A 0.5-mL sample of the resulting suspension was diluted until nearly clear, centrifuged, and decanted. The pollen walls were then chemically cleaned by acetolysis and mounted in silicone oil (Faegri and Iversen 1975) for microscopic examination. For each sample a minimum of 300 pollen grains was identified and counted, and the percentage frequency calculated.

Reference pollen was collected from flowers of plants in bloom within 2 km of the colony. This pollen was also treated with acetolysis and compared to unknowns in the pellet samples. Microscopic examinations were at 400-diameter magnification. Photomicrographs were taken with a Zeiss Ultraphot II using Kodak High Contrast Copy film. All photomicrographs were enlarged to 1000×.

Pollen from the surface mud of Pinehurst Lake at 43°55′N, 81°02′W and 10 km (6 mi) northwest of the bee yard was examined after sediment preparation (Faegri and Iversen 1975) to compare wind-dispersed pollen with that collected by Honey Bees.

Results

Forty-six taxa were found in pellets during the 1976 season. Major components are pollen taxa with 10% or more for at least one day; secondary components range from 1 to 10% and minor components are less than 1%. The major components (Figure 1), include *Acer* (maple),

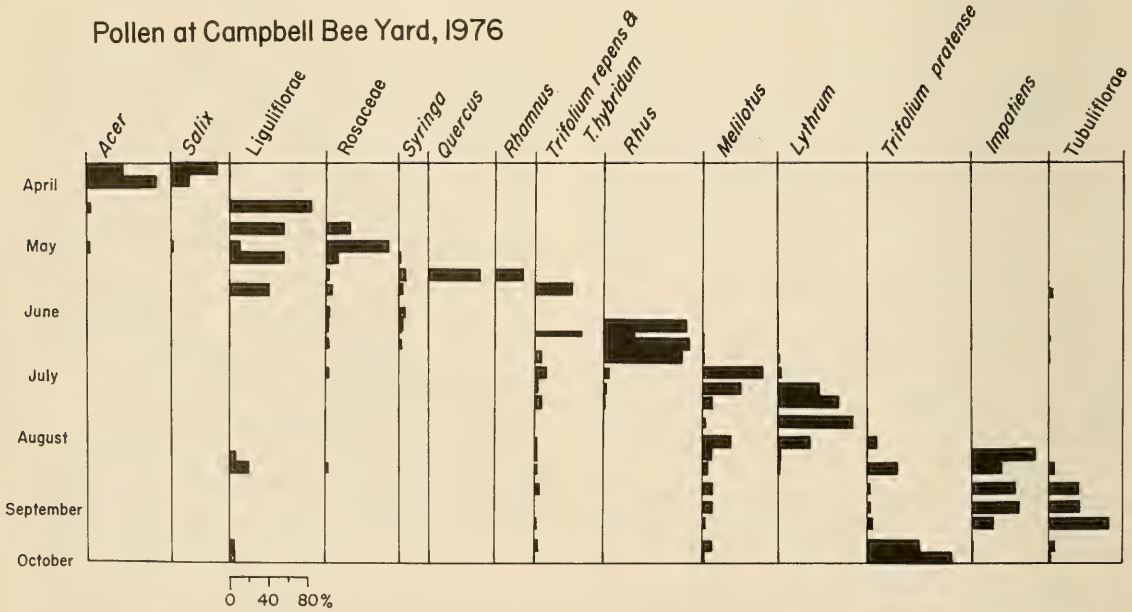

FIGURE 1. Seasonal progression of the major and secondary pollen components in Honey Bee pellets from Campbell Bee Yard, southern Ontario. The shaded areas indicate months.

Salix (willow), Liguliflorae (dandelion, lettuce, chicory), Rosaceae (plums, cherries, hawthorn, apples, pears, and roses), *Quercus* (oak), *Rhamnus* (buckthorn), *Trifolium repens* (White Clover), *T. hybridum* (Alsike Clover), *T. pratense* (Red Clover), *Rhus* (sumac), *Melilotus* (sweet clover), *Lythrum* (loosestrife), *Impatiens* (jewel-weed), and Tubuliflorae (goldenrod, yarrow, etc.).

The secondary components (Figure 1, Table 1) were *Syringa* (lilac), *Symplocarpus* (skunk cabbage), Ranunculaceae (buttercups), *Lonicera* (honeysuckle), *Aesculus* (horse chestnut), *Cornus* (dogwood), *Hamamelis* (witch hazel), Cruciferae (mustards), Liliaceae (lilies), *Sambucus* (elderberry), Umbelliferae (carrots, Queen Anne's lace, etc.), *Medicago* (alfalfa), *Lupinus* (blue-bonnet), Labiatae (mints), and *Arctium* (burdock).

The minor components (Table 1) include Onagraceae (evening primrose, fireweed), *Ribes* (currant), Gramineae (grasses), *Thalictrum* (meadow rue), *Elaeagnus* (Russian olive), *Lotus* (trefoil), *Vicia* (vetch), *Echium* (blueweed), *Lespedeza* (bush clover), *Catalpa* (catalpa or Indian bean), *Saponaria* (soapwort), *Plantago* (plantain), *Echinocystis* (wild cucumber), Caryophyllaceae (pinks, chickweeds), and *Cirsium* (thistle).

Identification of Pollen from Pellet Samples

Useful comprehensive guides to pollen identification and the terms used to describe pollen grains are presented by Faegri and Iversen (1975) and Kapp (1969). An illustrated key to fossil pollen that occurs in lake sediments of the Great Lakes region (McAndrews et al. 1973) emphasizes primarily wind-dispersed pollen rather than those taxa gathered by insects. Some taxa such as *Acer* and *Quercus* appear both in bee pellets and in lake sediment.

Photomicrographs (Figures 2, 3, 4) show the major and distinctive taxa found in bee pellets during 1976. Other taxa that may occur can be tentatively identified with the guides cited above. Collection of reference pollen and records of flowering times for plants growing in the foraging area are also useful in identification of unknowns.

The major characteristics used in pollen identifications are number, position and shape of apertures, wall sculpture, grain shape and grain size. Pollen found in bee pellets may have one to four or more furrows (Figures 2d, e, f, and 4f), furrows with equatorial pores (Figure 3a), a combination of simple furrows and furrows with pores (Figure 2l, m, n) or four or more pores regularly spaced over the surface (Figure 2j). Further, the surface sculpture of pollen grains may be smooth (Figure 2f), or may have radial projections (Figures 3b, and 4f, j), striations (Figure 3l, m), a reticulum or network (Figure 2b, c, n, o), or depressions in the outer pollen wall (Figure 2h). The shape in side or equatorial view varies from spherical, with the polar axis larger than the equatorial diameter or with the equatorial diameter larger than the polar axis. The shape of pollen grains in polar view may be circular, triangular, rectangular, or hexagonal. The combination of such characters provides information for identification of pollen grains to family, genus or even species, eg. Leguminosae (Adams and Smith 1976). Although it is possible to separate Rosaceae into genera and species, we have not done so here. Compositae is divided into two major groups, Tubuliflorae and Liguliflorae, but more refined generic identifications are possible.

Comparison of Pollen Presence and Frequency

At the beginning of each season, the overwintering bees retain the ability to forage from productive pollen and nectar crops. Thus they begin the year's collecting in early spring by exploratory foraging on any potential crop, sometimes erring by collecting small particles such as dust and fungal spores that lack nutritional value (Stanley and Linskens 1974).

Figure 1 shows the seasonal progression of major pollen taxa collected by Honey Bees during 1976. In southern Ontario, the earliest pollen collections are from anemophilous forest trees and early-blooming entomophilous herbs. Pollen of the entomophilous rose family is abundant, as is the early-blooming dandelion (*Taraxacum* of the Liguliflorae). *Rhus* replaces *Trifolium repens* and *T. hybridum* in mid-June; *Trifolium* again dominates pellet collections in late June, with *Rhus* as a minor component.

Trifolium pratense bloomed shortly after *T. repens* and *T. hybridum,* but did not appear continuously in pellets until mid-August along with *Lythrum, Impatiens,* and Tubuliflorae. *Trifolium pratense* was then abundant until the

TABLE 1—Percentages of secondary and minor components of pollen pellet analysis

Collection day	*Symplocarpus*	Ranunculaceae cf. *Caltha*	*Lonicera*	*Aesculus*	*Cornus*	Onagraceae	*Ribes*	Gramineae	*Thalictrum*	*Elaeagnus*	*Lotus*	*Vicia*	*Tilia*	*Viburnum*	*Echium*	*Lespedeza*	*Catalpa*	*Plantago*	*Hamamelis*	*Echinocystis*	Cruciferae	Liliaceae	*Sambucus*	Umbelliferae	Caryophyllaceae	*Medicago*	*Cirsium*	*Lupinus*	Labiatae	*Arctium*	*Althaea*
April 18	4.1	1.3																		0.5	10.7									
29		5.0																												
May 9		2.1																		2.5										
16		4.4																		0.9	0.1	12.4								
22		0.8	1.4	4.4																2.6		7.8								
29			0.2	1.9																4.4										
June 4					0.5																			0.1						
12					6.8	0.4														0.5			0.5							
21					2.4	0.4	0.1	0.2	0.4	0.4	0.1	0.1								1.0			0.5		4.6					
28								0.3		0.2	0.2		0.2							0.6		1.1			0.5					
July 4								0.4	0.5				0.4	0.1						3.9		0.8			0.5					
11																				0.3					5.5	0.5	1.8			
18												0.2			0.2	0.2				1.3				0.2	5.7	0.6	3.0	0.7		
25																				3.7				0.2	1.5		0.2	0.3	3.8	
Aug 1																0.3					8.6				1.3		0.3	2.2	5.8	
10																					1.8		2.2	0.7					2.3	
16																				1.5	0.7		0.3	0.6	5.0				0.2	
22															0.2		0.3			0.2			1.0	0.2	3.4		0.5			
Sept 1																														
8																				0.5					0.2					
15																									0.9					
22																		1.2			2.4			0.6		0.3	7.5		0.6	
Oct 1																			0.2	0.2	0.5						0.9	0.2		0.2

FIGURE 2. Pollen from spring pellet collections: a, *Symplocarpus* (skunk cabbage) equatorial view (ev); b, c, *Salix* (willow) ev; d, *Acer* (maple) ev; e, *Acer* polar view (pv); f, liliaceae (lilies) ev; g, Ranunculaceae, c.f., *Caltha* (marsh marigold) oblique view (ov); h, liguliflorae, c.f., *Taraxacum* (dandelion) pv; i, *Sambucus* (elderberry) ov; j. Cruciferae (mustards) pv; k, Rosaceae, c.f., *Pyrus* (apples, pears) pv; l, Rosaceae, c.f., *Prunus* (plums and cherries) ov; m, Rosaceae pv; n, *Syringa* (lilac) ov; o, *Syringa* pv; p. *Lonicera* (honeysuckle) ov.

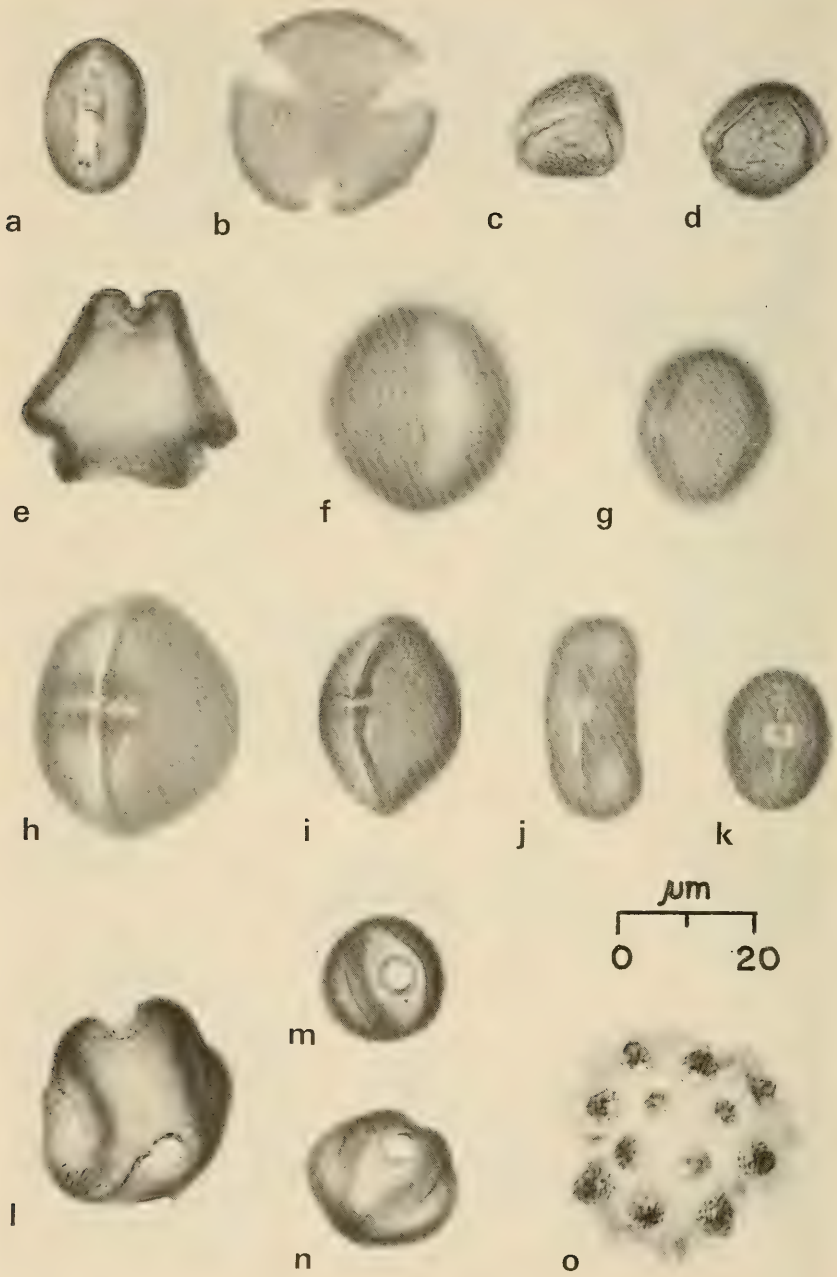

FIGURE 3. Pollen from spring and summer pellet collections: a, *Aesculus* (horse chestnut) ev; *Quercus* (oak) pv; c, *Rhamnus* (buckthorn) ov; d, *Rhamnus* ev; e, *Cornus* (dogwood) pv; f, Rosaceae, c.f., *Crataegus* (hawthorn) ev; g, *Trifolium hybridum* (Alsike Clover) ev; h, *Rhus,* c.f., *typhina* (Staghorn Sumac) ev; i. *Rhus,* c.f., *radicans* (Poison Ivy) ev; j, k, *Melilotus* (sweet clover) ev; l, *Lythrum* (loosestrife) ov; m, n, *Lythrum* ev; o, *Circium* (thistle) pv.

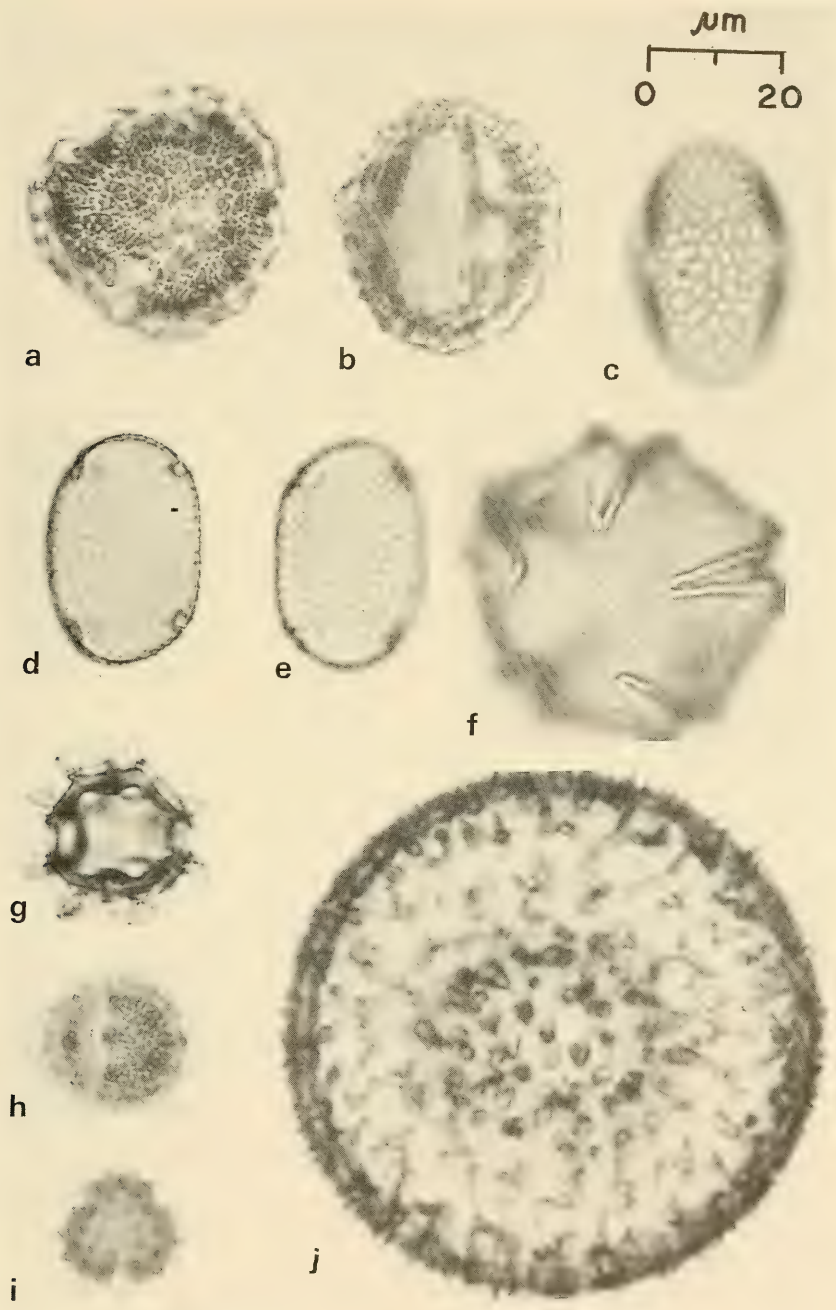

FIGURE 4. Pollen from summer and fall pellet collections: a, *Arctium* (burdock) ov; b, *Articum* ev; c, *Trifolium pratense* (Red Clover) ev; d, e, *Impatiens* (jewel-weed) pv; f, *Echinocystis* (wild cucumber) ov; g, Liguliflorae, c.f., *Cichorium* (Chicory) ov; h, Tubuliflorae, c.f., *Chrysanthemum* (ox-eye daisy) ev; i, Tubuliflorae, c.f., *Solidago* (golden-rod) pv; j, *Althaea* (hollyhock) ov.

end of sampling on 1 October 1976. The second occurrence of Liguliflorae reflects late-blooming weeds such as *Cichorium* (chicory), *Lactuca* (lettuce), and *Sonchus* (sow thistle). Although there was a garden within 10 m of the apiary, virtually no pollen of *Solanum* (potato) or *Lycopersicum* (tomato) appeared in pellet collections. Pollen of the locally abundant *Saponaria* (soapwort) and *Echinocystis* (wild cucumber) was infrequent (Table 1). Further study in southern Ontario will document variation from hive to hive and from season to season, with the expected sequence of anemophilous forest trees followed by entomophilous fruit trees and herbs.

In contrast to insect-distributed pollen, airborne pollen is randomly distributed over a wider area and is preserved in lake sediment and bog peat. Relative frequencies of airborne pollen found in southern Ontario were documented by Webb and McAndrews (1976). Table 2 compares a mud-surface sample from Pinehurst Lake with pellet data from the Campbell Bee Yard and from England. The pellet study from southern England is remarkably similar both in the relative frequency of woody-plant and herb pollen and in land-use patterns at both sites (10 to 15% of both areas is presently forested). Pellet studies from southwestern Scotland, where forest cover reaches 40%, have different taxa in Honey Bee pellet collections (McLellan 1976) and include *Pinus, Picea, Abies, Alnus, Ostrya,* and *Fagus* — all anemophilous forest taxa. Pollen of anemophilous herbs (*Ambrosia, Artemisia,* the Cyperaceae, and *Rumex*) rarely occurs in bee pellets, even if the proportion of open or arable land where the plants are abundant is large.

In surface sediments of Pinehurst Lake, *Quercus* comprises 22% of the pollen counted and *Betula* 7%; both taxa occur in bee pellets, but in low percentages. Other taxa such as *Acer, Juglans, Tilia, Salix*, Gramineae, Tubuliflorae, Liguliflorae, *Populus,* and *Plantago* occur in lake sediment and in bee pellets in comparable amounts. *Rhamnus, Rhus, Aesculus, Sambucus, Cornus, Lythrum,* Leguminosae, Rosaceae, Liliaceae, *Impatiens,* Ranunculaceae, Cruciferae, Umbelliferae, Cucurbitaceae, Onagraceae, and *Hamamelis* are found only in bee pellets; of these, *Rhamnus, Rhus, Sambucus, Cornus, Impatiens,* Umbelliferae, and *Hamamelis* occur in the Ontario samples, but are absent for those in Britain. Conversely, *Castanea, Buxus,* Papaveraceae, and *Viola* are found in English samples, but not in the collections from Ontario; the difference probably reflects opportunity rather than inclination to collect.

Further comparison of tree and shrub percentages with the percentages of herbaceous taxa in Table 2 shows that woody pollen taxa are more frequent in airborne spectra (about 70%) than in pellet samples (about 30%) from southern Ontario. Herbaceous pollen percentages are similarly high in pellet samples both from southern Ontario and southern England. The percentages are reversed in forested regions. The percentages of Leguminosae are high in England as compared to Ontario. The average of Leguminosae collected in Scotland (McLellan 1976), 14.9%, is lower than in Ontario. Comparatively high percentages of Cruciferae both in England and Scotland may reflect the cultivation of *Brassica* species (kales).

The differences between surface samples and pellet collections are more striking if the number of entomophilous and anemophilous taxa are compared. In pellet samples from southern Ontario, England (Synge 1947), and Scotland (McLelland 1976), 20 to 40 taxa are from entomophilous plants and from three to seven taxa are anemophilous. Pollen from entomophilous taxa comprise 91 to 95% of the total annual pollen collected by Honey Bees; the remaining 5 to 9% are from anemophilous taxa. The reverse situation occurs in surface samples from lake mud and bog surfaces, where 94 to 95% of the pollen is from anemophilous taxa. The number of anemophilous taxa ranges from 17 to 21%. Only two to five taxa of entomophilous plants comprise the remaining 5 to 6% of lake and bog pollen assemblages in southern Ontario and Scotland (Birks 1972).

Discussion

The kind and proportion of pollen in Honey Bee pellets vary from place to place depending upon the flora available as determined by land use within a foraging area. The variation expected from hive to hive and from year to year in any one location depends upon the collective foraging of any one hive and on pollen avail-

TABLE 2—Comparison of percentage frequencies of pollen from lake sediments and from annual collections of bee pellets. E4 and K5 are separate but adjacent hives studied during the same year. A plus sign (+) indicates less than 1%; an asterisk (*) indicates entomophilous taxa

	Southern Ontario		England	
	Pinehurst Lake	Campbell Bee Yard	E4 (from Synge 1947)	K5
Quercus (oak)	22	2	1	
Pinus (pine)	13			
Betula (birch)	7			1
Ulmus (elm)	6		1	1
Acer (maple)	4	5	2	2
Fagus (beech)	4			
Fraxinus (ash)	3		2	2
Ostrya (ironwood)	3			
**Salix* (willow)	2	3	+	2
Cupressineae (cedar, juniper)	2			+
Picea (spruce)	1			
Tsuga (hemlock)	1			
Alnus (alder)	1			
Abies (fir)	+			
Juglans (walnut)	+	+		
**Tilia* (basswood, linden)	+	+		
*Rosaceae (fruit trees, roses)	+	5	17	17
**Rhus* (sumac)		13		1
**Rhamnus* (buckthorn)		1		
**Sambucus* (elderberry)		1		
**Aesculus* (horse chestnut)		1	1	+
**Cornus* (dogwood)		+		
Populus (aspen, poplar)		+	2	3
**Buxus* (boxwood)			+	1
Castanea (chestnut)			+	+
Woody pollen total	72	33	27	30
Ambrosia (ragweed)	12			
Gramineae (grasses)	7	+		1
Cyperaceae (sedges)	2			
Rumex (sorrel, dock)	2			+
*Leguminosae (legumes)		25	59	49
**Lythrum* (loosestrife)		10		
*Liguliflorae (dandelion, etc.)	+	10	2	4
**Impatiens* (jewel weed)		9		
*Tubuliflorae (goldenrod, etc.)	+	8	+	2
Artemisia (sage)	+			
Chenopodiineae (goosefoot)	+			
*Cruciferae (mustards, kales)		1	6	7
*Onagraceae (fireweed)		+	1	2
Plantago (plantain)	+	+		1
*Liliaceae (lilies)		1	+	1
*Ranunculaceae (buttercups)		1	+	1
*Cucurbitaceae (cucumbers)		+	1	1
*Papaveraceae (poppies)			1	+
**Viola* (violet)			+	1
*Umbelliferae (parsley, etc.)		+		
**Lonicera* (honeysuckle)		+		
**Symplocarpus* (skunk cabbage)		+		
*Saxifragaceae		+		
*Scrophulariaceae			+	+
Herbaceous pollen total	27	66	72	70

ability. Pollen availability is determined by the phenology of any plant taxon and plant response to weather conditions. Anthropogenic factors such as harvesting or weed eradication also affect pollen availability.

Bees forage on available pollen sources regardless of the floral adaptations that distinguish certain flowers as "bee flowers." We have observed bees collecting from such anemophilous taxa as *Populus tremuloides* (aspen), *Ambrosia* (ragweed), and *Quercus* (oak) in other parts of North America. Taxa considered as anemophilous (Faegri and van der Pijl 1971) on the basis of floral morphology are collected by bees. Anemophilous forest taxa are more numerous in bee pellets where forest cover is greater although their percentages are low (about 9%). In southern Ontario and southern England, where entomophilous crops and weeds of Eurasian origin dominate the rural landscape, bees collect pollen from anemophilous taxa in early spring before the entomophilous taxa flower.

The combined study of wind-dispersed pollen and pollen collected by Honey Bees offers a new dimension to both types of investigation. The pollen rain reflects only regional wind-dispersed pollen. Pollen from bee pellets reflects both native and introduced vegetation as well as flowering times. Combining such studies may eventually provide a more complete picture of pollination and pollination ecology in relation to both the native and the introduced (or exotic) flora.

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Spatial Pattern and Population Dynamics of *Populus tremuloides* in a Saskatchewan Aspen Grove

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Archibold, O. W. and M. R. Wilson. 1978. Spatial pattern and population dynamics of *Populus tremuloides* in a Saskatchewan aspen grove. Canadian Field-Naturalist 92(4): 369–374.

The spatial pattern of nine 5-yr age-classes of trees in a grove of Trembling Aspen *(Populus tremuloides)* was studied by applying nearest-neighbor analysis to a transect, 10 × 60 m. Three marked differences of pattern were noted in the transect: random spacing of trunks in the peripheral part of the transect, more regular spacing in the transition zone, and a return to nearly random spacing at the core. From the literature on aspen ecology these results are interpreted as localized differences in age structure and density within a single clonal population, with cycles of replacement that are of shortest duration at the periphery of the grove where moisture stress is most frequent and severe.

Key Words: aspen groves, spatial pattern, nearest-neighbor analysis, age-classes, transect.

Previous studies of the geographical distribution of Trembling Aspen *(Populus tremuloides)* have been conducted either as broad ecological surveys (Bird 1961; Maini 1960; Maini and Cayford 1968) or as historical accounts in which change in the range of the species has been documented with respect to land settlement (Watt 1960). More detailed surveys have been of the forest inventory type with any information on stand characteristics and local distribution patterns obscured in generalized growth and yield data (Kirby et al. 1957; Steneker 1976), although extensive work has been carried out on delineating the boundaries of individual aspen clones (Barnes 1966). Techniques of pattern analysis such as those developed by Greig-Smith (1957) and Kershaw (1957) have typically been applied to herbaceous vegetation, although mean square/block size analysis of this type has been applied by Shinn (1971) to an old-growth cedar-hemlock stand. The study by Whitney and van Groenewoud (1964) of the rate at which fungal infection thinned a White Spruce stand is exceptional in that a map of the stand is given, but no quantitative assessment of the resulting patterns was made. Analysis of spatial pattern is limited by the fact that the general problem of pattern analysis in plants has proved to be awkward biologically as well as mathematically (Pielou 1969, p. 122).

Trembling Aspen grows in a wide range of plains and montane environments across northern North America but is best represented in the "Aspen Grove Section" of the Boreal Forest Region (Rowe 1972), the southern margin of which is fragmented with the trees occurring as groves interspersed with grass prairie and cropland. Throughout this region groves of aspen are most often found on land too sandy or stoney to be broken even for improved pasture. The site selected for study is within an area of fixed sand dunes about 30 km SW of Saskatoon, Saskatchewan (52°2½′N, 106°51′W); the study transect extended from a level area that had been cleared for haying down a slope of about 4° to an elongated, infrequently flooded depression. The length of time that the selected aspen grove has gone without disturbance is not known, but the age of the oldest trees, about 50 yr in 1977, and the time when prairie fires were effectively suppressed, about 1919 (Raby 1966), provide upper and lower estimates.

This study describes the distribution pattern of individual trees in a prairie aspen grove and postulates some processes through which such patterns could have developed.

Methods

Preliminary inspection of aspen groves on dune sands in central Saskatchewan showed large older trees predominating in or near swales, or around the margins of willow-filled depressions that are close to the water table. A single-clone portion of one grove was identified by means of crown notch evidence (Barnes 1966,

p. 445). A transect 10 m wide was surveyed across the margin of the grove through the depression at its center and a series of survey stations was set up from which to plot the position of each tree by bearing and distance.

Measurements were made of trunk diameters at 1.2 m aboveground level (dbh) for each tree in the mapped transect. Thirty trees, selected as a representative though not strictly random sample of trunk diameters, were cored at the same height in order to produce a graph of dbh against ring-count age (Figure 1). The annual rings of aspen, like those of many other hardwoods, are not easily distinguished and many methods have been proposed to solve this problem (Maini and Coupland 1964). A very simple method and one which served well in this research was to dip the air-dry cores into hot black coffee for about 1 min. Air was expelled from the porous wood and the rings were clearly visible while they remained wet. Dead trees were included in the mapping and their dbh measured, a distinction being made between dead trees still standing and stumps with rotting trunks beside them. To evaluate the spatial pattern of trees, we divided the transect into six quadrats of 10 × 10 m and applied nearest-neighbor analysis (Clark and Evans 1954) to the mapped distributions. The significance of the nearest-neighbor index (R) was tested using the z-score technique of King (1969).

The value of R is found by defining a sample area, measuring the mean distance from each point (in this case, tree trunk) to its nearest neighbor, then dividing by the mean distance to be expected from a corresponding number of points randomly distributed over the same area. Mean random distance is calculated as the reciprocal of twice the square root of points per unit area, or $\frac{1}{2\sqrt{N/A}}$. R approaches 0 for completely clustered points, is 1.0 for a random distribution, and reaches 2.15 for a perfectly uniform pattern. The z-score for R is a two-tailed test in which the difference between observed and random mean distances is divided by the standard error of the random mean distance (King 1969, p. 100). It provides a probability of chance occurrence for a given R value; no test of the significance of differences between R values exists.

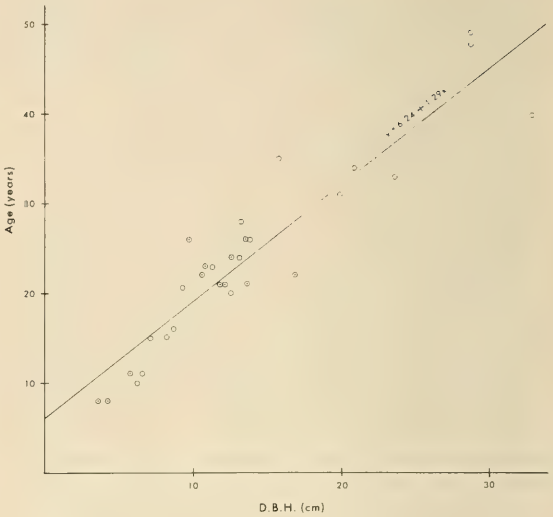

FIGURE 1. Relationship between diameter at breast height (dbh, measured at 1.2 m) and age of Trembling Aspen trees (y = 6.24 + 1.29 x).

Results

Because of the absence of clear break points in the age distribution of the sample an arbitrary 5-yr division was used to derive the age-class data presented in Figure 2. Three zones can be distinguished: periphery (0 to 10 m), transition (10 to 40 m), and core (40 to 60 m). The periphery of the grove represents a zone of active reproduction characterized by an abundance of young trees less than 10 yr old. No trees older than 30 yr were found here and only one dead tree was present. Within the transitional zone the number of young trees steadily declined with only four young individuals found in the 30- to 40-m quadrat. Older trees increased in number, but none were older than 35 to 39 yr. Dead trees and stumps are common in this zone, particularly in the 20- to 30-m quadrat. Within the core zone of the grove only five older trees were encountered with all other individuals in the youngest age class.

Analysis of spatial patterns in the transect is based on Figure 3, which shows the distribution of the trees, with associated data presented in Table 1. The density measurements depend somewhat on the choice of quadrat boundaries but the general pattern is not obscured. Density is greatest at the periphery of the grove (0.53 individuals/m^2), decreases to 0.17 individuals/m^2 in the fourth quadrat, and rises slightly

FIGURE 2. Age-class distributions for Trembling Aspen trees in each 10-m quadrat of the transect.

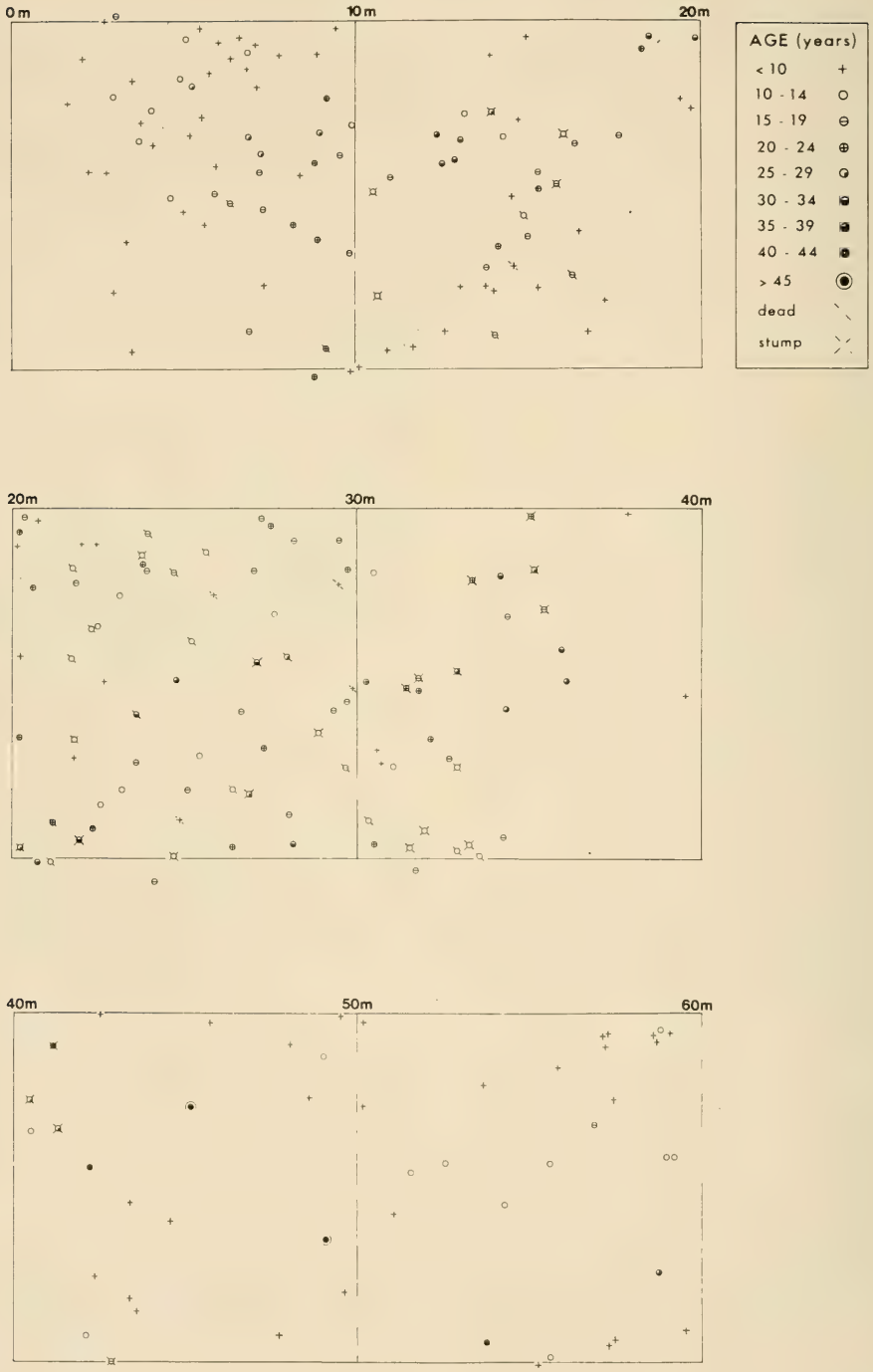

FIGURE 3. Spatial pattern of Trembling Aspen trees in the transect.

TABLE 1 — Summary of transect data

Quadrat position on transect (m)	0–10	10–20	20–30	30–40	40–50	50–60
Mean distance between nearest neighbors (m)	1.71	1.90	2.18	3.65	3.67	2.13
Density (indivs/m^2)	0.53	0.34	0.37	0.17	0.18	0.24
Basal area live indivs (cm^2)	2090	2400	2730	2240	2560	1410
Basal area dead indivs (cm^2)	184	467	2160	1240	960	0
R (for live trees)	1.06	0.95	1.14*	1.29*	1.33**	0.89

*$P<0.05$.
**$P\leq 0.01$.

(0.24 individuals/m^2) at the core of the grove where young trees are recolonizing. Although the transect includes large variations in density these are smoothed out in the basal area totals. Live basal area values increase slightly from 2090 cm^2 in the first 10 × 10-m quadrat to a maximum of 2730 cm^2 in the third, then drop to a minimum of 1410 cm^2 at the core of the grove. Basal area values for dead trees in the transect vary much more sharply, but also reach a peak in the third quadrat where a value of 2160 cm^2 was recorded. At the periphery of the grove the trees are arranged in a random pattern, while in the transition zone, where trees of medium age and size produce a maximum total basal area, one also finds the greatest regularity of spacing. At the core of the grove, where neither old nor young trees occupy all available root or crown space, the pattern once more approaches randomness.

Discussion

Underlying the pattern of ages, densities, and spacings that have been described there must be causal factors, some aspen-specific and some habitat-specific. Mature aspens are well known for intolerance to flooding, slight tolerance for moisture stress, and extreme intolerance to shading (Maini 1960). Reproduction through seed germination in aspen is considered to be rare and also appears to be controlled by very narrow moisture requirements; vegetative reproduction or 'suckering' is far more common giving rise to genetically identical clones (Barnes 1966, p. 441). For abundant and vigorous suckering, strong light and heat must reach the forest floor so that conditions most favorable to suckering are found in openings in, or on the periphery of, aspen groves.

The patterns in our transect might reflect any of several histories for the grove. Expansion into surrounding herbaceous cover would give the observed periphery of young trees, but southward and upslope expansion of aspen groves on sandy soils is unlikely because that combination elevates moisture stress (Maini 1960, pp. 175, 177–178). Given the small (0.05 acre, or 14 × 14 m) mean clone area mentioned by Barnes (1966, p. 445), our transect could include or cross-cut several clones, each with distinct histories and characteristics of propagation and longevity. The observed changes along the transect can be fitted to this case but the nonexistence of methods to test the significance of differences among nearest-neighbor index values allows no direct conclusion from our data; nevertheless we suspect that it is not the case. Both Maini (1960, p. 171) and Barnes (1966, p. 444) remark on the tendency for aspen roots to parallel linear moist depressions like the one our transect crosses. Although neither author deals with competition between clones in these conditions, from their general observations we infer that several clones aligned with a soil moisture gradient would produce an unstable situation.

Expansion of a clone is determined both by physical conditions and by competition with neighboring clones, and suckers under the canopy of neighboring clones typically die from insufficient insolation unless significant thinning occurs through some disturbance (Barnes 1966, p. 445). The extreme annual variability of precipitation in the interiors of continental landmasses leads to frequent periods of water stress (Maini 1960, p. 170). Hence not only is

expansion into surrounding areas limited but significant thinning should allow expansion of favored clones to occur periodically. Where a gradient of moisture availability is steep enough to stress one clone more than another, the clone at the wetter end of the gradient can be expected to 'capture' the drier end through more vigorous suckering. It follows logically that clone-to-clone boundaries should radiate from moist depressions, but this requires confirmation by further study.

The profile of age composition along the transect is therefore interpreted as a series of growth cycles within a single clone, increasing in duration toward the core zone. Trees in the periphery (0 to 10 m) appear to have a shorter maximum life span than those nearer the core, although repeated sprouting keeps the zone well stocked with suckers. Through the transition zone (10 to 40 m) trees attain ages up to 40 yr, although the stand is nevertheless thinned by deaths of individuals of all ages. Periodic 'die-offs' are mentioned by Graham et al. (1963, p. 91), but it is not clear whether these are attributed to aspen–aspen competition, environment–aspen stress, or a combination of these. In the core zone (40 to 60 m) a few trees live to ages in excess of 45 yr; after these die the absence of middle-aged trees will give the false appearance of a grove expanding into the central depression.

Acknowledgments

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Migratory Movements and Plumage of Subadult Saskatchewan Bald Eagles

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From 1967 to 1975 we banded 296 Bald Eagles (*Haliaeetus leucocephalus*) in Saskatchewan. Of these, 56 banded as nestlings at Besnard Lake during 1973–75, were also wing-marked. One hundred and three sightings of wing-marked individuals and 13 band recoveries, all subsequent to departure of the birds from their breeding grounds, show a fall movement through southern Saskatchewan to wintering rounds across a broad region extending from Montana to Missouri, Texas, and southern California. One individual was seen in November 1974, 1975, and 1976 at the Squaw Creek National Wildlife Refuge in Missouri. Summer sightings showed that some of the second, third, and fourth-year individuals returned to the lake where they were raised, while one bird was seen in summer about 480 km NW of its lake of origin. One bird was found dead in its fourth fall in Alaska, indicating intermixing between interior and coastal eagle populations. Our observations of known-age birds suggest some differences from previous descriptions of plumage development at various ages.

Key Words: Bald Eagle, subadult, migration, plumage, survival, Saskatchewan, wing-marking.

We previously reported the existence of a large breeding population of the Bald Eagle (*Haliaeetus leucocephalus*) in the boreal forest of Saskatchewan (Whitfield et al. 1974). In 1967 we began banding eagles in this region. Colored vinyl wing-markers were also applied to nestlings of this species raised on Besnard Lake, starting in 1973. Our objectives were to learn where Saskatchewan eagles wintered, what the migration routes were, whether the nestlings returned as subadults to spend their summers near Besnard Lake, and the nature of yearly plumage changes. In addition, since the marking technique was a relatively new one, we felt it important to evaluate its advantages and disadvantages.

It has been known for some time that large numbers of Bald Eagles winter in the western United States, particularly along the Missouri and Mississippi Rivers and at wildlife refuges (Sprunt and Ligas 1964). Recent observations have also shown significant eagle concentrations in virtually all states west of the Mississippi River with the exception of North Dakota and possibly Nevada (Spencer 1976). A very large fall concentration occurs southwest of Saskatchewan at Glacier National Park (McClelland 1973) where eagles feed on spawning Kokanee Salmon (*Oncorhynchus nerka*). Though most fall and winter concentrations are associated with water bodies, the sizeable ones in the Utah desert occur away from water, with birds feeding primarily on Black-tailed Jack Rabbits (*Lepus californicus*) (Platt 1976). A considerable winter population of Bald Eagles is also regularly found along the Pacific coast in British Columbia and Alaska (Spencer 1976). The wintering areas used by eagles originating in Saskatchewan were not known, although seven sightings of marked birds in the fall of 1973 (Gerrard et al. 1974) had suggested southerly rather than westerly fall migration. Since 1973 we have obtained much more information on the movements of subadult Saskatchewan Bald Eagles. These data are the subject of the present report.

Methods

Between 1967 and 1975, inclusive, we banded 296 Bald Eagles (294 nestlings, 1 flying juvenile in hatching year, and 1 adult) in north-central Saskatchewan (Whitfield et al. 1974; Gerrard et al. 1976). The only two other recoveries of Saskatchewan Bald Eagles, a result of 11 nestlings banded by M. R. Lein and C. S.

Houston, are also included in the evaluation of migratory movements.

From 1973 to 1975, colored vinyl wing-markers were applied to 56 of the 57 nestlings banded at Besnard Lake, about 55 km WNW of Lac La Ronge in central Saskatchewan. This lake supports 20–25 breeding pairs of Bald Eagles. The construction and method of applying these wing markers were originally described by Kochert (1973) and have been discussed in detail by us (Gerrard et al. 1974). In 1973 and 1974 eagles were marked to allow individual identification. In 1975, with two exceptions, eagles were marked only to identify the hatching year. Reports of sightings of wing-marked birds were evaluated on the basis of correspondence, or personal or telephone interviews with the observers.

For calculation of survival of marked birds (Table 1), we used only the 43 birds individually marked in 1973 and 1974. The percentage of the 43 alive at the end of each calendar year was calculated using the total number of different individuals seen after 31 December of that year. For analysis of survival of banded birds we used the method of Brown and Amadon (1968) to calculate survival, except that instead of presenting data in terms of percent mortality, we used percent survival. Thus, a 79% mortality of birds in their first year (data from Brown and Amadon 1968) is listed as a 21% survival in Table 1. The 95% confidence intervals for the percentages in this tabulation were obtained from published tables (Rohlf and Sokal 1969), and statistical comparisons were made using the chi-square test.

Each verified report of a marked bird that differed from other reports by date or location was considered a separate sighting. But for purposes of analyzing the direction and latitude of eagles during migration and wintering periods (Table 2), all sightings of one bird seen on more than one occasion at the same location within a one-month period, were grouped and considered as one. For this purpose, the total of 63 sightings away from Besnard Lake was condensed to 43 records. Recoveries of banded birds, except those that had been dead some time, were also included in the analysis in Table 2. The Student's "t" test was used for statistical comparison of the data.

Results

Evaluation of the Wing-marking Technique

We (including Houston and Lein) obtained 11 band recoveries (4.4%) from 251 non-wing-marked birds banded up to 1975. In contrast, we obtained 103 reports of sightings and 4 band recoveries from a minimum of 24 of the wing-marked birds (43% or more), clearly indicating a higher information return for wing-marked birds. Forty of these sightings were of birds that had returned in their second, third, or fourth summer to Besnard Lake, while the remaining 63 sightings were reports from other locations. One bird was sighted on nine separate occasions and another on seven occasions over a period of 4 yr; this allows some understanding of the year-to-year pattern of movement. Success with the markers was partly offset by some limitations. Loss of markers, sighting of only one or two of the markers, or uncertainty over color of one or more of the markers, resulted in the possibility in many cases of assigning only the place of origin (Besnard Lake). The very nature of visual identification at a distance leads to some degree of uncertainty with the data. As a result, reports of sightings had to be carefully checked; a quarter of all reports were rejected owing to lack of an adequate description of the bird species or the marker. Mortality of one bird was linked to the marking; it was found dead the following year as if it had jumped from its nest and hooked its marker on a branch.

Of the 43 birds marked as individuals in 1973 and 1974, at least 8 different individuals (19%) were sighted at some time after 31 December of their third year of life (Table 1). Since some birds alive after this time were probably not seen and others may have lost markers, this figure represents a minimum survival rate. By comparison, 3 of 15 known (from recovery data) deaths of Saskatchewan eagles occurred after the third year of life, suggesting a 20% survival to three years. This figure must also be considered a minimum, since eagles are long-lived birds and future mortality reports of older birds may be expected. Owing to the small numbers of birds involved in both these samples, with resulting wide confidence intervals, and owing to the fact that both estimates must be considered minimal, there is no significant difference in the two results. Both survival rates

TABLE 1—Survival of wing-marked and banded Bald Eagles

	% alive at end of first calendar year		% alive at end of second calendar year		% alive at end of third calendar year	
	x	95% CI	x	95% CI	x	95% CI
Wing-marked birds (1973, 1974)	37(16/43)	22–53	*23(10/43)	11–40	**19(8/43)	9–36
All birds banded in Saskatchewan and recovered	53(8/15)	26–80	27(4/15)	7–69	**20(3/15)	4–48
Previously published data based on band recoveries (Brown and Amadon 1968)	21(23/107)	13–31	9(10/107)	4–17	4(4/107)	1–10

*Includes one marked bird found dead which had lost its markers but retained its band.
**Significantly different from previously published data ($P < 0.05$).

generated from our data, however, are significantly higher than the only previously published value (Table 1).

Migratory Movements

Beginning in October, marked birds migrated gradually southward from Besnard Lake, reaching the most southerly average latitude during February and then returning north in March, April, and May (Table 2). From November to February the mean latitude of older immatures was south of the mean latitude of first-year birds ($P < 0.1$, t = 1.86, df 22) suggesting that older immatures may move south first, or migrate faster or farther than immatures in their first season. In March to May the situation is reversed, suggesting that first-year birds tend to lag behind while older immatures travel northwards first. The direction of migration in October and November was 166° ± 18° ($x \pm$ SD). In December and January the direction of sightings from Besnard Lake was 171° ± 17°, while in February to May it was 179° ± 26°. There was a trend for sightings to be further west in spring (February–May) than in fall (October–November) ($P < 0.1$, t = 1.94, df 30).

In the fall and winter, sightings showed a tendency to be near lakes or along rivers, a tendency for birds to remain in a favorable area for several weeks at a time and to return to a favorable site in consecutive winters. Thus 58 of 62 sightings away from Besnard Lake between September and May were of birds near a lake or river or ocean; in December of 1974, two second-year birds were seen repeatedly in the area just below the Fort Peck Dam in northeastern Montana, one 6 times from 3 to 20 December, and the second 6 times from 3 to 23 December. On 21 November 1974 at Squaw Creek National Wildlife Refuge (NWR) in Missouri, one marked bird was seen with all three markers clearly identified. Several reports of a marked bird with only one or two markers seen clearly

TABLE 2—Movement of Saskatchewan Bald Eagles as revealed by latitude of sightings and compass direction of sightings from nest

Month	Birds in first and early second year of life			Birds in second–fourth year of life			All birds		
	No. of sightings	Latitude, °N	*Direction from nest,°	No. of sightings	Latitude, °N	Direction from nest,°	No. of sightings	Latitude, °N	Direction from nest,°
September	0			2	55.3		***3	55.3	98
October	6	**50.8 ± 4.1	166 ± 14	0			10	48.9 ± 5.8	168 ± 19
November	6	45.9 ± 6.7	164 ± 16	6	40.5 ± 5.7	165 ± 20	12	43.2 ± 6.6	164 ± 17
December	3	43.7 ± 1.6	187 ± 8	4	43.8 ± 5.0	177 ± 19	9	42.8 ± 3.6	174 ± 19
January	1	44.0	168	2	41.7	179	6	42.2 ± 4.2	167 ± 12
February	1	47.0	213	1	32.7	170	4	38.5 ± 6.6	195 ± 19
March	3	39.3 ± 8.9	166 ± 18	3	42.6 ± 4.3	185 ± 35	7	41.2 ± 5.9	173 ± 26
April May	2	43.7	169	2	54.2	210	5	48.3 ± 6.1	173 ± 30
June	0			6	55.3		8	55.3	
July	3	56.2		14	55.3		22	55.4	
August	1	55.3		6	55.3		8	55.3	

*Excludes birds within 100 km of the nest site.
**Mean ±SD (Standard deviation is given only for groups of three or more).
***Totals do not necessarily add, as the age of some birds was uncertain.

FIGURE 1. Sightings and recoveries of Bald Eagles in September, October, and November. ■ — first fall, ● — second to fourth fall, ▲— age uncertain, b — band recovery, ⊙— Besnard Lake. Where more than one sighting was made at one location the numbers adjacent to the symbol indicate the minimum number of individuals/the total number of sightings.

suggest that this eagle had been on the refuge since 19 October. It was possibly also present in its first fall, 1973, when two of three markers were seen clearly, and was definitely present 21 and 30 November 1975, in its third fall, and again 7, 8, and 27 November 1976 in its fourth fall. In 1974, this eagle was also seen 22 December at Swan Lake NWR about 240 km ESE of Squaw Creek. Repeated sightings in two successive winters of birds with two markers (i.e., one marker lost and therefore the identity of the bird not established conclusively) at Fort Peck, Montana, and Swan Lake, Missouri, also support the concept that eagles may visit the same wintering area in successive years.

The one report from Alaska (Figure 1) was of a bird marked as a nestling in 1973 and found dead 32 km S of Juneau in November 1976. The bird was in an advanced state of decay and clearly had been dead for some time. Though we have tentatively included it in the fall records, it is conceivable that the bird had died the previous summer. We had no sightings of this bird in the summer and therefore do not know whether it was spending the summers in Alaska or farther east.

Spring sightings and band recoveries (April and early May) were of four different birds: 8 April at Squaw Creek, Missouri; 1 May on the Charles M. Russell National Wildlife Range, Montana; 2 May at Big Stone NWR, Minnesota; and 1 May at Glenbush, Sas-

katchewan about 250 km SW of Besnard Lake.

Forty sightings over the course of four summers show that an appreciable percentage (9–19/56 = 16–32%) of marked immatures returned to summer (13 May – 13 September) on Besnard Lake where they had been raised. The uncertainty in the return rate is owing to several sightings of a bird or birds marked in 1975 when the same color pattern was used on many birds. In addition, since some of the unmarked immatures seen may have been marked but had lost all their markers, this may be an underestimate. Some immatures had not returned to Besnard Lake. One marked bird was sighted in July of its second year at Pierson Lake, Alberta, about 480 km NW of Besnard Lake. The marked bird seen repeatedly on its wintering grounds at Squaw Creek NWR and the one found in Alaska were not seen in the course of repeated thorough searches of Besnard Lake, and probably had summered elsewhere. Nine sightings of one marked bird on Besnard Lake and the nearby Mercer River in three successive summers show that this bird wandered over a range at least 32 km in length. Our sightings give no indication that immatures have summer home ranges as small as those of breeding adults (unpublished).

Additional support for the tendency of eagles to return to the locale where they were raised comes from a nestling banded by Lein in 1964 at a site just south of Fond du Lac, Saskatchewan, about 400 km N of Besnard Lake. This bird was shot the following June about 60 km northwest of where it was raised.

Plumage Patterns of Marked Bald Eagles

Southern (1967) described seven plumages of the Bald Eagle based on study skins of unknown-age birds which he thought might represent six or seven year classes. Sightings of known-age marked birds have given us more information on changes in plumage pattern of immatures. Those seen in their first year had the predominantly dark brown plumage described by Southern. A variable amount of lighter brown was sometimes present on the head, back, and tail. White feathering was present only on the underside of the wings, and on one bird in a mottled pattern on the breast. One bird seen in its second fall was still predominantly brown but had some mottled white coloration on the back and breast and was in an early stage of what Southern called the "Osprey-like" head pattern with a dark brown line through the eye and mottled white above and below. It appeared similar to Southern's plumage C/D which he considered to represent third- to fourth-year birds. Four birds in their third summer had a much more pronounced "Osprey-like" appearance with the head predominantly whitish with a darker brown band through the eye. The plumage of the back, upper wings, and breast was variable, but all contained some mottled white. The tail was predominantly white, with a dark brown terminal band and a variable amount of flecked brown in the rest of the tail. Two birds in the summer (July) of their fourth year and one bird in the fall (November) of its fourth year had almost achieved adult plumage. On the head, one still had a small amount of dark brown through the eye, while two still had flecks of brown on the crown. Two still had some brown on the terminal edge of the tail, while the tail of the third was almost entirely white.

Discussion

The wing-marking technique used in the present study has proven to be extremely useful for studying eagle movements. The rate of return is very much higher than from conventional banding. The concentration of eagles on their wintering grounds has allowed a high rate of sightings of marked birds. With eagles being more evenly spread out and in less populated areas in the summer, sightings then are somewhat less productive though locally useful. The ability to identify birds individually was valuable, though owing to loss of some markers individual identification was frequently impossible. Analysis of survival data provides some information on survival of Bald Eagles and wing-markers, and indicates that wing-markers do not cause a significant increase in eagle mortality. Indeed, our results suggest that previous findings may have overestimated eagle mortality in the first three years. In one case the marker was implicated in the death of a nestling, and we therefore urge caution in the use of this technique.

Our findings show that Saskatchewan Bald Eagles disperse in the winter over much of the western United States. All fall and winter

FIGURE 2. Sightings and recoveries of Bald Eagles December to March. Legend as in Figure 1.

sightings, with the exception of one bird which went to Alaska, were within a triangular area between south-east (148°) and south-west (218°) of Besnard Lake. No sightings were obtained from the Mississippi River valley or from Glacier National Park, which lie just east and west, respectively, of this triangle, in spite of many observers and many other eagles sighted in these locations. We can therefore feel reasonably confident that these bearings encompass the wintering area of the majority of eagles raised on Besnard Lake. As the Saskatchewan eagles are a part of a population, breeding on or just south of the Canadian Shield, which continues east into Manitoba and Ontario and west into Alberta and the Northwest Territories (Godfrey 1966), we suggest that eagles wintering along the Mississippi River come primarily from east of Besnard Lake, while those congregating in the fall at Glacier National Park come predominantly from areas west of Besnard Lake.

The direction of eagle migration in October and November is predominantly south-southeast. This movement into the Dakotas, Kansas, and Missouri follows the pattern of other Saskatchewan raptors including Marsh Hawks (*Circus cyaneus*), Red-tailed Hawks (*Buteo jamaicensis*), and Swainson's Hawks (*Buteo swainsoni*) (Houston 1967, 1968a, b). In December to March many of the eagles are found in areas west and south of this initial dispersal, suggesting that there may be a secondary movement westward in mid-winter. The wide dispersal of marked birds originating

from one lake shows that the winter distribution is not specific to the lake of origin. The discovery that a few cross the Rocky Mountains and even go as far as southern California and Alaska, suggests that there is some mixing of the birds of the Pacific coast with those of the continental interior. This may have important consequences for long-distance gene flow in the species.

During migration and wintering periods, Saskatchewan-raised eagles continue to be predominantly associated with aquatic habitat, as they are in summer (Whitfield et al. 1974). One sighting and one band recovery in Utah suggest that a few birds may intermix with the eagles wintering in that state which feed primarily on terrestrial mammals. Most eagles in late fall and early winter, however, were found at places like Fort Peck and Squaw Creek, where they feed on crippled waterfowl and also on fish (R. Shupe, D. Knauer, G. Nugent, personal communication). At Squaw Creek eagles reach peak numbers as high as 263 in December or early January (Spencer 1976). Eagles generally depart in late winter from Squaw Creek NWR in Missouri and Fort Peck Dam in Montana as the food supplies decrease, and the winter wanderings of eagles may be best represented as a gradual southward movement with periodic stopovers continuing till late winter, with an equally gradual return northward in early spring. For example, the bird which was observed at Squaw Creek, Missouri, in 1974, 1975, and 1976 during November, was at Swan Lake farther southeast in December of 1975 at least. Extent of the movement southward of individual birds appears to vary, some going as far south as Texas and California during the winter and others remaining as far north as Montana and South Dakota during the coldest months of the year.

Clear-cut data from one individually marked bird and suggestive data from other sightings support the belief that once eagles have found wintering areas, they tend to return there in succeeding years, if only for part of the winter. In summer, many of the eagles return to their lake of origin, while others summer elsewhere.

Plumage descriptions of putative year classes of immature Bald Eagles were made previously by Southern (1967). Our observations fit the general pattern of Southern's descriptions, though we found considerable variability in the plumage of back and breast of third-year birds, and we suggest more rapid maturity than Southern thought.

In our personal observations of between 500 and 1000 nesting Bald Eagles, we have not seen even one in incomplete adult plumage. Our observations also indicate that the eagles molt extensively during the summer months, and we regard it as very unlikely that the 3½-year-old immature seen in near but not full adult plumage in late November at Squaw Creek NWR, Missouri, would carry no trace of its immature markings by early summer. Thus we tentatively conclude that this bird would not have bred at 4 yr of age and suggest 5 yr as the minimum for its sexual maturity. But, we cannot exclude the possibility that other eagles, such as the one seen in its fourth July, i.e., aged 3 yr, at Besnard Lake with an all-white tail and a few brown speckles on the head, might not be in breeding plumage and breed at age 4.

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Notes

Use of an Old-field Habitat by Bobolinks and Red-winged Blackbirds

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The habitat preferences of Bobolinks (*Dolichonyx oryzivorus*) and Red-winged Blackbirds (*Agelaius phoeniceus*) nesting in a 15.4-ha field on the Luther Marsh Wildlife Management Area, Ontario were determined during 20 May – 30 June 1977. Eight blackbird and 10 Bobolink nests were found during the 6-wk period. Red-winged Blackbirds nested exclusively in monotypic stands of *Phalaris arundinacea* (Reed Canary-grass) which comprised less than 20% of the 15.4-ha field. Blackbirds preferred nesting cover that (1) was close to water, (2) matured relatively early in the season, and (3) had the structural strength to support their nests. Bobolinks, in contrast, avoided *P. arundinacea* and used residual grasses and weeds for nest construction and cover. No definable relationship could be found between Bobolink nesting behavior and the living vegetation in the field.

Key Words: *Dolichonyx oryzivorus, Agelaius phoeniceus,* nest locations, habitat preference.

The habitat preferences of Red-winged Blackbirds (*Agelaius phoeniceus*) nesting in upland sites have been noted by Robertson (1972), Francis (1973), and others. Such sites supported plant communities commonly dominated by goldenrod (*Solidago*), Alfalfa (*Medicago sativa*), fleabane (*Erigeron*), clover (*Trifolium*), various thistles (e.g., *Cirsium*) or other herbaceous weeds, all of which may be used for nest support (Robertson 1972). The habitat requirements of nesting Bobolinks (*Dolichonyx oryzivorus*) have not been well defined; consequently little is known of their preferences for particular plant communities. The purpose of this study was to determine the habitat preferences of nesting Bobolinks and Red-winged Blackbirds within an old-field community.

Materials and Methods

The study was conducted from 20 May through 30 June 1977 in a 15.4-ha (300 × 515 m) field on the Luther Marsh Wildlife Management Area, Dufferin County, Ontario. The field included 14.6 ha of moderately dense (living vegetation) to dense (residual vegetation) ground cover plus two ponds and two small unvegetated mud mounds. The study area and adjoining fields to the north, south, and west had remained uncultivated for 8–9 yr and supported similar plant communities. A fourth field situated east of the study field was plowed in mid-June 1977 but remained uncultivated.

Habitat within the field was classified into four types according to the plant species visually estimated to be dominant: (1) monotypic stands of *P. arundinacea,* or *P. arundinacea* mixed with *Vicia cracca* (Tufted Vetch) and *Lotus corniculatus* (Birdfoot Trefoil); (2) *Salix* stands; (3) mixed stands containing *Solidago canadensis* (Canada Goldenrod), *V. cracca, L. corniculatus*, and grasses as dominants (no *P. arundinacea*); and (4) ponds and unvegetated mud mounds. The total area of each type was calculated by measuring small stands with a 30-m tape and by pacing the perimeter of larger homogenous tracts. Each type was delineated on a scaled habitat map.

To obtain frequency and dominance ratings plus litter depths, I randomly chose 30 plots from a grid overlay superimposed on the habitat map and sampled each plot once at the midpoint with a 0.5-m^2 quadrat. Three locations in ponds were rejected and replacements were drawn. Vegetation was identified using Peterson and McKenny (1968) and Fassett (1957) or the herbarium collection at the University of Guelph.

Eight bird counts were conducted in the 6-wk period. Counts involved walking 10 transects spaced at 50-m intervals and extending the width of the field. All Red-winged Blackbirds and Bobolinks found within the field or perched on fence posts separating the study field from adjacent fields were counted, sexed, and their locations marked on the map. The maximum number of birds counted on any one survey was considered to represent the number of birds using the field for nesting and foraging. A direct count was used because of the minimal area involved (15 ha) and because of the excellent visibility afforded by vegetation rarely exceeding 30–50 cm in height (Kendeigh 1944). The timing of the counts varied, with four conducted in the morning (0600–1000) and

four in the late afternoon (1500–1700) or early evening (1900–2000)

Nests were located by searching the study area 3 times weekly. Linear transects at 10-m intervals were walked and each nest, when located, was marked with red flagging tape to avoid duplicating nest records. Additional nests (primarily Bobolink) were located by marking sites where females were first seen and, at a later time, revisiting those locations in order to flush the female from the nest site. This resulted in minimal disturbance to vegetation and nesting pairs. No attempt was made to ascertain the fate of each nest.

Results

The frequency of occurrence and dominance ratings for 10 plant species found in the study field are given in Table 1. Six of the species dominated the living groundcover and, combined with the residual vegetation, provided a dense blanket of potential nesting cover (about 50% for living vegetation, and 93% for residual and living vegetation combined) averaging 30–50 cm in height. Living grasses other than *P. arundinacea* were encountered frequently (67% of the quadrats) but were usually clumped and of limited stature (rarely exceeding 20 cm). Litter depth, while varying throughout the field, averaged 10.4 cm (range 0–20 cm) but provided poor to excellent cover depending on the location sampled.

Phalaris arundinacea in monotypic and mixed stands covered approximately 3.2 ha (21% of the total area), whereas *S. canadensis, V. cracca, L. corniculatus,* and the various short-statured grasses existing as mixed stands covered an additional 11.3 ha (73%). The *Salix* stands contributed 0.11 ha or 1% of the ground cover.

Bobolinks accounted for 58% (34) of the estimated 59 birds regularly using the field. Although they are normally polygynous (Martin 1974), I found male Bobolinks outnumbered females 18 to 16. I may have consistently missed some of the secretive females during surveys, or included within the counts males whose territorial boundaries extended beyond the boundaries of the study plot. Female Bobolinks paired with males and nesting within the study field were counted while those nesting outside the field were not.

A total of 25 Red-winged Blackbirds was observed using the study field. The eight counts indicated a sex ratio of 0.92 male: 1 female. Red-winged Blackbirds, like Bobolinks, are frequently polygynous (Dolbeer 1976). If surplus males (Nero 1956) were present, they were not identifiable as such.

Eighteen nests (8 Red-winged Blackbird, 10 Bobolink) were found during the 6-wk period. Three Bobolink clutches were complete when discovered and the other 15 nests were located during the egg-laying period. The eight Red-winged Blackbird nests were constructed of dead grasses and were placed exclusively in monotypic stands of *P. arundinacea.*

TABLE 1—Estimated frequency of occurrence and dominance ratings for plant species found in an old-field habitat at Luther Marsh Wildlife Management Area, Ontario, 1977[1]

Species	Frequency (%)	Dominance ratings[2]		
		First	Second	Third
Tufted Vetch (*Vicia cracca*)	77	5	7	5
Unidentified grasses (*Gramineae*)	67	9	8	3
Reed Canary-grass (*Phalaris arundinacea*)	47	7	1	5
Canada Goldenrod (*Solidago canadensis*)	47	4	5	5
Birdfoot Trefoil (*Lotus corniculatus*)	37	6	3	1
Panicled Aster (*Aster simplex*)	33	2	4	3
Alsike Clover (*Trifolium hybridum*)	27	1	1	4
Field Sow-thistle (*Sonchus arvensis*)	27	1	0	5
Common Dandelion[3] (*Taraxacum officinale*)	17	—	—	—
Sedge[3] (*Carex* sp.)	10	—	—	—

[1]Frequency of occurrence calculated from 30 0.5-m^2 quadrats.

[2]Dominance ratings were determined by visually ranking the three dominant species in each of the 30 quadrats sampled. If two species within one quadrat were estimated to be equal in dominance, each was given a comparable rating for that quadrat (e.g., two species sharing a rating of first).

[3]Species were never dominant in a quadrat.

The females relied entirely on dead *P. arundinacea* stems (from the previous year's growth) to support the nests and on the new living vegetation for cover. The nests had a mean (± SE) height of 15.0 ± 1.3 cm (range 10–20 cm) above the ground in *P. arundinacea* averaging 58.4 ± 2.8 cm (range 51–71 cm) in height. *Phalaris arundinacea* stands used by nesting Red-winged Blackbirds varied from 0.13 m^2 to 5.3 m^2 in area (mean = 1.2 ± 0.7 m^2).

The 10 Bobolink nests were uniformly constructed of residual grasses (excluding *P. arundinacea*) and weeds with the top of the nests flush with the top of the litter layer. Living vegetation surrounding the nests ranged in height from 33 to 41 cm (mean ± SE, 37.6 ± 0.84 cm) and consisted predominately of *S. canadensis* (occurred within 20 cm of seven nests), *V. cracca* (four nests), *T. officinale* (four nests), and *L. corniculatus* (two nests). As a result of small sample sizes, no apparent preference for any of these plants could be detected. All the Bobolink nests had a canopy or overlay consisting of dead grasses which was, on the average, 10.0 ± 0.6 cm (range 5–20 cm) above the top of the nest. The thickness of the canopy varied, but was usually less than 5 to 10 cm.

Discussion

Of the 10 plant species most frequently encountered during quadrat sampling (Table 1), only *P. arundinacea* was used extensively for nesting. *Phalaris arundinacea* was used principally by Red-winged Blackbirds and, perhaps owing to the height of the protective canopy provided by the grass blades (Francis 1973) and to the density and overall height of the vegetation (Robertson 1972), it appeared to be one of several factors influencing the placement of nest sites (and presumably territories) within the study field. Portions of the field devoid of *P. arundinacea* (approximately 12 ha) were virtually unused by Red-winged Blackbirds. A second factor of seemingly equal importance to these birds was the availability of fence posts, which served as display perches for the males and as observation points for both sexes (Nero 1956). Stands of *P. arundinacea* lacking fence posts or *Salix* stands remained generally unused by the blackbirds. Water also seemed to influence the distribution of the blackbirds. Ten of the 12 males were located near the two ponds, while the other two males confined their activities to *P. arundinacea* stands adjacent to a flooded ditch averaging 1–2 m in width with water 10–18 cm in depth. Less than 2.9 ha contained all of *P. arundinacea,* fence posts, and water, and only this area was used by nesting Red-winged Blackbirds. Other plant species in the field had little visible influence on placement of nests, or on the daily activities of the adults prior to the brood-rearing period. They did, however, play an important role later since Red-winged Blackbirds actively searched the goldenrod-vetch-trefoil mixed stands for lepidopteran larvae to feed to the nestlings.

There was no obvious definable inter-relationship between Bobolink nesting behavior and most of the plant species found in the field, except for the use of residual grasses for nesting and of *S. canadensis* as perches by both sexes. Male Bobolinks also perched on fence posts, wire fencing, dead vegetation, and occasionally *Salix* branches, but seemed to prefer the stalks of goldenrod. This observed preference for *S. canadensis* as a perching site by both males and females may have reflected nothing more than the plant's availability within the field (Table 1), or the unobstructed view provided by the tall stalks. It remains questionable that the use of the field could be attributed to the presence or abundance of, and preference for, *S. canadensis* as a perching site, since Bobolinks were also observed in fields lacking this plant. No attempt was made to compare Bobolink pair densities in fields with and without *S. canadensis.*

The habitat preferences of nesting Bobolinks were not as clear-cut as those of the Red-winged Blackbird. The consistent use of *P. arundinacea* by nesting blackbirds was probably a result of the plant's early availability and maturity, its close proximity to the two ponds and to a flooded ditch bisecting the field, and because it provided a satisfactory support for the blackbirds' nests (Robertson 1972). The other herbaceous weeds within the community apparently failed to meet one or more of these criteria and were less desirable. Bobolinks, in contrast, arrived somewhat later on the study area than did the blackbirds (10–15 May versus 25 April – 10 May, respectively) and, being ground nesters, did not gear their nesting activities to the availability and desirability of early-growing herbaceous weeds. Rather, they used residual grasses and weeds for nest construction and for cover. New growths of vegetation were used primarily as perching sites and, later, as a source of lepidopteran larvae for nestlings.

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Long-distance Movements of Arctic Foxes Tagged in Northern Alaska

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A total of 193 Arctic Foxes (*Alopex lagopus*) have been ear-tagged in northern Alaska since March 1975. Eighteen tagged foxes have been recovered since their release; seven involved long-distance movements ranging from 129 to 945 km, some of which were apparently made irrespective of local food availability. Maximum average travel rate during long-distance movements was 24 km/d.

Key Words: *Alopex lagopus*, tag returns, movements.

Arctic Foxes (*Alopex lagopus*) are well-known for their long-distance movements. Most records of these movements are based on observations of unmarked foxes far from their normal breeding range, either on the Arctic ice pack (Chesemore 1968) or unusually far inland (Wrigley and Hatch 1976). There are few studies documenting the actual distances moved by individual foxes. This paper presents results on tag returns from an intensive Arctic Fox research program conducted in northern Alaska as a part of ecological studies of the consequences of petroleum resource development in that region.

Study Area and Methods

Arctic Foxes were live-trapped, ear-tagged, and released periodically during March 1975 to August 1977 in the Prudhoe Bay oil field area, the Franklin Bluffs construction camp on the Trans-Alaska pipeline route, and the Colville River delta (Figure 1). Foxes were captured in live traps at rearing dens during the summer and at construction camps and garbage dumps during the late fall, winter, and spring. Each animal was anesthetized with ketamine hydrochloride (Ramsden et al. 1976). Markings used to identify individual foxes included a round teflon ear tag of our own design; Standard Rototags (Nasco Agricultural Sciences, Modesto, California); and colored nylon-coated vinyl ear streamers. All tags were serially numbered and stamped with a return address. A $20-reward was offered for the return of the tags. Notification of the reward was stamped on the tag and printed on posters that were distributed to several villages surrounding the study area.

Indices to lemming (*Dicrostonyx groenlandicus*) population densities were obtained from live-trapping grids (Battelle Columbus Laboratories 1973) in 1971–1973 and 1975–1977. In addition, snap-trapping lines similar to those used by Pitelka (1973) were used in 1975–1977.

Results and Discussion

A total of 193 Arctic Foxes was ear-tagged since 1975; 164 animals were marked at the Prudhoe Bay study site, 16 on the Colville River delta, and 13 at the Franklin Bluffs construction camp. Eighteen tagged animals have been recovered since the study began; eight of these foxes were killed by trappers, five by vehicles, one was shot, and four died from unknown causes. The 4% ear-tag return rate from trappers during this study was considerably less than the 15% trap return rate reported by Urquhart (1973, p. 81) during a 2.5-yr study on Banks Island, Northwest

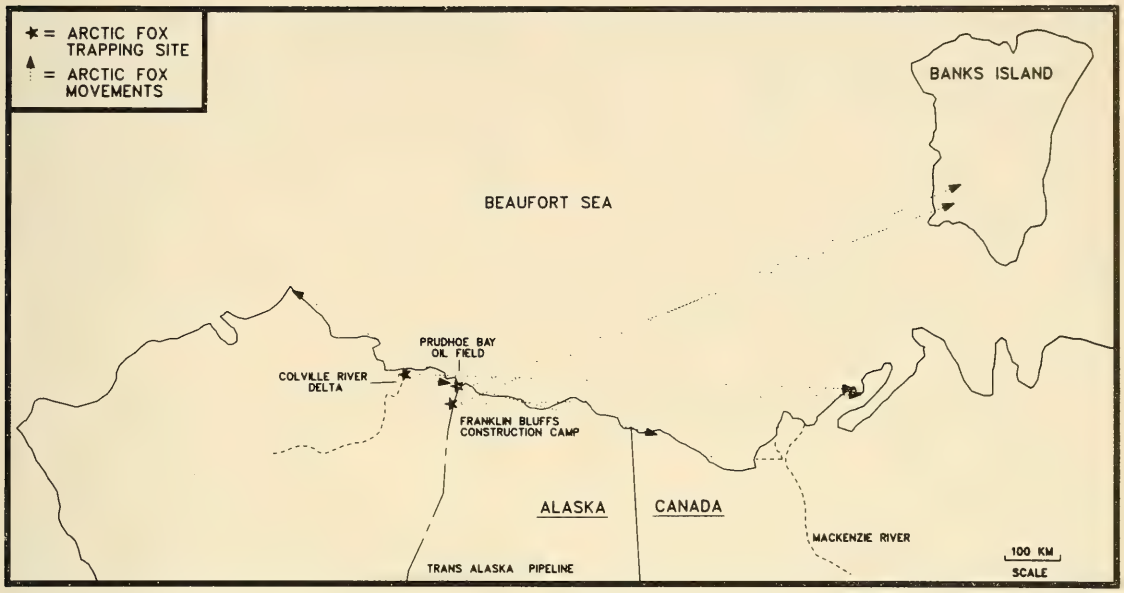

FIGURE 1. Long-distance movements of Arctic Foxes tagged at the Prudhoe Bay, Franklin Bluffs, and Colville River delta study sites in northern Alaska during the period March 1975 to August 1977.

Territories and the 14 and 16% rates for studies conducted in the USSR (Smirnov 1967, p. 84). The reasons for this difference are unclear but presumably relate to differences in local trapping pressure.

Seven long-distance movements by tagged Arctic Foxes were documented during this study (Figure 1, Table 1). Distances moved from initial tagging locations ranged from 129 to 945 km. These movements are comparable to the results of small-scale Arctic Fox tagging studies conducted in Canada where movements of 107 km (Northcott 1975), 444 and 304 km (Urquhart 1973), 1000 and 1530 km (Wrigley and Hatch 1976), and 1127 km (Macpherson 1968) were recorded.

The results of the small-mammal trapping indicated that lemming population densities were high to moderate in 1975 and 1976 and very low in 1977.

TABLE 1—Long-distance movements made by Arctic Foxes tagged in northern Alaska

Sex	Age (months)	Location, date tagged	Location, date of return	Method of return	Distance moved (km)	Number of days
Male	>9	Prudhoe Bay, 16 March 1975	Firth River, N.W.T., May–June 1975	Observation	338	35–81
Male	>9	Franklin Bluffs Const. Camp, 17 March 1975	Banks Island, N.W.T., 28 March 1976	Trap	945	376
Male	>9	Franklin Bluffs Const. Camp, 18 March 1975	McKinley Bay, N.W.T., 15 April 1975	Trap	676	28
Male	>7	Prudhoe Bay, 11 January 1977	Banks Island, N.W.T., 2 April 1977	Trap	901	81
Male	3	Colville River Delta, 9 July 1976	Tuktoyaktuk Peninsula, N.W.T., March 1977	Trap	781	234–265
Female	3	Colville River Delta, 10 July 1976	Prudhoe Bay, Alaska, 9 January 1977	Shot	129	183
Female	3	Prudhoe Bay, 14 July 1976	Barrow, Alaska, 21 December 1976	Trap	330	160

Comparison between lemming densities, the major prey of Arctic Foxes (Eberhardt 1977), and fox movements indicate that long-distance movements were made in both high and low lemming years, which suggests that at least some movements are made irrespective of local food availability.

Sheldon (1953) reported that male Red Foxes (*Vulpes vulpes*) tend to travel more than females. General observations made by several other authors indicate that male Arctic Foxes also tend to roam more than females, particularly during the winter (Bannikov 1969; Pulliainen 1965; Vibe 1967). Although no statistically significant ($P = 0.47$; chi-square test) difference was observed between male and female mobility in our study, this may be a result of the small number of tag returns. A tendency for male Arctic Foxes to travel more than females during the winter could explain the significantly higher ($P < 0.01$; chi-square test) proportion of males trapped during our study in the fall and winter months at construction camps and garbage dumps where large numbers of foxes congregate. This disparate sex ratio was not observed during the summer trapping when capture rates for males and females were equal ($P > 0.05$; chi-square test) for both adults and juveniles.

Average travel rates of foxes making long-distance movements during this study were estimated at less than 1 km/d to about 24 km/d if it is assumed that the capture dates reported by the trappers were correct. The maximum travel rate for tagged Arctic Foxes, as calculated from the literature, was 20 km/d (Urquhart 1973, p. 87), which closely corresponds to the average rate of 24 km/d observed in our study. These rates were similar to the maximum rate of 27 km/d observed for Red Foxes radiotracked during dispersal (Storm et al. 1976, p. 40) despite the differences in techniques used to measure the movements.

The results obtained during this study demonstrate the ability of Arctic Foxes to make long-distance movements in relatively short periods of time. This mobility is of obvious survival value during periods of local food shortage, particularly in the Arctic where the food base is limited and cyclic in nature. Because some long-distance movements are made during apparently "good" food years, some causal factors in addition to food, may be involved. The significance of these long-distance movements is not fully understood, but the movements probably affect the spread of rabies and other Arctic Fox diseases and may extend the impact of local arctic resource development on Arctic Fox populations.

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Some Vascular Plants New to the Flora of Saskatchewan

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Recent field and herbarium studies have resulted in the discovery of 13 species of vascular plants which are reported here as new to the flora of Saskatchewan. These are *Astragalus yukonis, Athyrium filix-femina* var. *michauxii, Cardamine parviflora* var. *arenicola, Cryptantha minima, Eleocharis parvula, Eriophorum scheuchzeri, Juncus nevadensis, Juncus tracyi, Nasturtium officinale, Panicum lanuginosum* var. *implicatum, Poa arctica, Polypogon monspeliensis,* and *Trientalis europaea* var. *arctica.*

Key Words: Saskatchewan flora, plant records, phytogeography.

During the course of recent botanical studies, particularly in northern Saskatchewan, numerous plant collections have been made by the authors or their assistants. Other plant specimens have been brought in to the Fraser Herbarium for our attention and earlier collections have been restudied. Reported here as new to the province of Saskatchewan are 13 species of vascular plants. These species are listed below in alphabetical order with their collection data and brief distributional notes.

Astragalus yukonis M. E. Jones [*A. bodinii* Sheld. var. *yukonis* (M. E. Jones) Boivin]; Yukon Milk-vetch.

South end of Sandy Bay of Churchill River, 8 km S of Island Falls Dam (55°29′N, 102°19′W), semi-disturbed, park-like, sandy beach, 12 July 1973, *V. L. Harms 20056* (SASK), 2 September 1975, *V. L. Harms 23102* (SASK), Island Falls area, about 1 km SE of dam (55°31′N, 102°20½′W), on abandoned trail, 3 September 1975, *V. L. Harms 23220* (SASK). This species has been known in northern Manitoba and northern Alberta (Boivin 1967b), but was never previously reported from Saskatchewan.

Athyrium filix-femina (L.) Roth var. *michauxii* (Spreng.) Farw.; Lady-fern.

About 15 mi [24 km] W of Southend, Numabin Bay of Reindeer Lake, Mile 1.3 (Km 2.1) of Highway 105 (Wollaston Lake Road) (56°16′N, 103°36′W), birch-alder-willow woods along small stream, 19 July 1973, *J. Ternier & M. Jasieniuk 2113* (SASK); 3.5 mi (3.6 km) N of Courtenay Lake, Mile 98 (Km 157) of Highway 105, (57°30′N, 103°58′W), moist birch woods at creek mouth, 22 June 1973, *J. Ternier & M. Jasieniuk 1420* (SASK); 5 mi (8 km) S of Geikie River bridge, Mile 110 (Km 176) of Highway 105, SW of Wollaston Lake (57°37′N, 103°54′W), moist birch woods along creek, 27 July 1973, *J. Ternier & M. Jasieniuk 2352* (SASK); Hidden Bay of Wollaston Lake, inlet from Parks Lake (58°08′N, 103°41′W), moist gallery White Birch-Black Spruce-River Alder mixed woods, 20 July 1975, *V. L. Harms 21605* and *21606,* 1 August 1976, *V. L. Harms & R. Wright 23757* (SASK). This report represents a northwestward range extension of approximately 550 km into northeastern Saskatchewan from the taxon's known occurrence in central Manitoba. Nevertheless, these records still leave a sizable gap of nearly 1000 km separating this eastern variety of the lady-fern from the western variety *sitchense* Rupr. [+ ssp. *cyclosorum* (Rupr.) C. Chr.].

Cardamine parviflora L. var. *arenicola* (Britt.) O. E. Schulz.; Small-flowered Bitter Cress.

Island at north end of Wapumon Lake on Churchill River (55°35′N, 102°56′W), open rocky shore, 5 July 1974, *J. & J. Heilman 2013* (SASK); Sokatisewin Lake on Churchill River, Island Falls Dam area (55°32′N, 102°21′W), open, rocky, formerly disturbed shore, 3 September 1975, *V. L. Harms 23319* (SASK). This species is known in western Alberta (Moss 1959; Boivin 1968) and in southeastern Manitoba (Scoggan 1957; Boivin 1968); thus, our Saskatchewan records help somewhat to bridge the apparent distributional gap.

Cryptantha minima Rydb.; Tiny Cryptanthe.

Westerham, between Leader and Estuary (SE Sec. 34, T 22N, R 28 W 3rd M), dry cindery soil near unused grain elevator office, 10 June 1977, *J. H. Hudson 3326* (SASK).

This species, which is characteristic of the western edge of the Great Plains region S of Saskatchewan from eastern Montana to western Texas, has previously been reported in Canada only from Medicine Hat, Alberta, by Boivin (1972). He speculated that it might represent an overlooked native plant of eroded soils, or possibly be an adventive there. The habitat of the present collection would favor, but hardly prove, the adventive theory.

Eleocharis parvula (Roem. & Schult.) Link var. *parvula;* Dwarf Spike-rush.

Goose Lake, about 40 mi [64 km] SW of Saskatoon (NW Sec. 22, T 32 N, R 10 W 3rd M), bare, damp, salt-flat shore between the high-water mark and water edge, 19 August 1977, *J. H. Hudson 3442* (SASK). This species has a wide distribution along both seacoasts of North America, as well as those of Europe and Africa. In North America, the more southern variety *anachaeta* (Torr.) Svenson, which lacks perianth bristles, ranges along the coasts of the Gulf of Mexico and Caribbean Sea. According to Hitchcock et al. (1969), the typical variety has been collected at scattered inland stations mainly E of the Mississippi River, while var. *anachaeta* has been found similarly at scattered inland sites W of the Mississippi River. For Canada, Boivin (1967a) did not report *E. parvula* from anywhere between Quebec and British Columbia, but Hultén's (1964) distribution map shows a dot near the Minnesota-Ontario boundary W of Thunder Bay. The nearest report of the species to our Saskatchewan locality appears to be from eastern South Dakota by Van Bruggen (1976), but this was of the var. *anachaeta.* Hence it is all the more interesting that our Saskatchewan material is of the typical variety with distinct perianth bristles as long as the achenes. But the impressive disjunction of the Saskatchewan station is likely more apparent than real, since the plants are small and similar enough to the common Needle Spike-rush, *E. acicularis* (L.) Roem. & Schult., to have been easily overlooked. It should be searched for on muddy shores of subsaline lakes.

Eriophorum scheuchzeri Hoppe.; Scheuchzer's Cotton-grass.

Southwest side of Trade Lake on Churchill River (55°21′N, 103°48′W), sedge shore fen, 8 August 1974, *J. & J. Heilman 2683* (SASK); Ray Bay of Wintego Lake on Churchill River (55°32′N, 102°52′W), sedge shore fen, 7 July 1974, *J. & J. Heilman 2055* (SASK). This arctic species has been known from northern Manitoba and western Alberta, but was previously unreported for Saskatchewan. What is perhaps most surprising is that the present records are from the Churchill River region rather than from northernmost Saskatchewan.

Juncus nevadensis S. Wats; Nevada Rush.

Fusilier, W of Kerrobert (NE Sec. 19, T 34 N, R 27 W 3rd M), damp grassy slough bottom in prairie, 18 July 1976, *J. H. Hudson 3196* (SASK); Court, W of Kerrobert (SW Sec. 26, T 34 N, R 28 W 3rd M), moist grassland edge of small slough, 21 August 1976, *J. H. Hudson 3237* (SASK); Cypress Hills West Block, NE of provincial park (SE Sec. 21, T 9 N, R 25 W 3rd m), 8 July 1957, *J. H. Hudson 1973* (DAO, distributed as *J. saximontanus* A. Nels.); Cypress Hills, alpine meadow, 24 June 1936, *J. P. Bolton, R. C. Russell* (SASK). The initial Cypress Hills determinations were confirmed by B. Boivin, Biosystematic Research Institute, Ottawa (personal correspondence with Hudson), who also indicated that to this taxon should be added the following sheets: Battle Creek Ranger Station in Cypress Hills (*Breitung 5148,* DAO), Birch Creek Ranger Station in Cypress Hills East Block (*Breitung 4852,* DAO), and Hoosier (*Jenkins 904, DAO).* The latter of these had been distributed as *J. mertensianus* Bong, and the former two as *J. saximontanus.* As the above collections indicate, *J. nevadensis* may be encountered in Saskatchewan not only in the Cypress Hills, but in the high country on the extreme western edge of the province between the South and North Saskatchewan Rivers. Presumably, the range of this otherwise cordilleran species might be expected to be more or less continuous from these Saskatchewan sites throughout southern Alberta to the Rocky Mountains, although Moss (1959) did not include the species for anywhere in Alberta. This species has never previously been reported for Saskatchewan, nor apparently for Canada, except in British Columbia, although specimen sheets now referred to it have been on hand for many years. Since it appears that all reports of *J. mertensianus* from southwestern Saskatchewan are based upon specimens now revised to *J. nevadensis,* the former species should best be excluded from the province for the present.

Juncus tracyi Rydb.; Tracy's Rush.

Cypress Hills East Block, Skull Creek S of Tompkins (NE Sec. 8, T 10 N, R 22 W 3rd M), in cold brook, 18 July 1974, *J. H. Hudson 2985* (SASK, USAS); Cypress Hills East Block, Ravenscrag (T 6 N, R 23 W 3rd M), gravelly steam edge, 23 July 1948, *G. F. Ledingham 48-572* (USAS, distributed as *J. saximontanus*); Cypress Hills West Block, along Battle Creek up from Fort Walsh (Sec. 2, T 8 N, R 30 W 3rd M), on flood plain next to White Spruce-poplar woods, 3 August 1962, *R. D. Newsome 229* (SASK). This is largely a cordilleran species of the western United States, reportedly extending eastward to Montana and Colorado (Hitchock et al. 1969). It has apparently not been reported previously for Saskatchewan by Fraser and Russell (1937, 1954), Breitung (1957), nor Boivin (1967a), although a specimen sheet now referred to the taxon has been on hand for 16 yr. It is difficult to evaluate the previous reports of the species from elsewhere in western Canada, as there has been too much past taxonomic confusion of both this species and the previous one, *J. nevadensis,* with *J. ensifolius* Wikstr. and its variety *montanus* (Engelm.) C. L. Hitchc. (= *J. saximontanus* A. Nels). To aid in distinguishing among these particular taxa so as better to locate specimen records that clarify their ranges, we include an abbreviated key below, modified in part from Hitchcock et al. (1969).

1. Leaves equitant, with septa incomplete (not extending across blade).
   2. Ripe heads spherical; seeds not tailed; styles inconspicuous.
      3. Stamens 3; leaf auricles lacking .... *J. ensifolius* var. *ensifolius*
      3. Stamens 6; leaf auricles often present .... *J. ensifolius* var. *montanus*
   2. Ripe heads hemispherical; seeds tailed; styles 1 mm long, conspicuous without magnification. .... *J. tracyi*

1. Leaves nearly terete (in life), only slightly grooved on side facing the stem; leaf septa complete across blade; ripe heads mostly low-conic. ..... *J. nevadensis*

Nasturtium officinale R. Br. [*N. microphyllum* (Boenn.) Rchb.; *Rorippa nasturtium-aquaticum* (L.) Hayek]; Water Cress.

Crooked Lake in Qu'Appelle River valley, 20 mi [32 km] S of Melville, (NW ¼ Sec. 19, T 19 N, R 6 W 2nd M), wet boggy area, 24 July 1975 and 15 July 1976, *V. Lieffers* (SASK). This introduced weedy species of wet places is widely naturalized in North America. In western Canada, it has been recorded as naturally established in southern Manitoba and southwestern Alberta to British Columbia (Boivin 1966, 1968), but to our knowledge not previously in Saskatchewan.

Panicum lanuginosum Ell. var. *implicatum* (Scribn.) Fern.; Tangled-wool Panic Grass.

Jaysmith Lake, Mile 90 (Km 144) of Highway 102 (55°59′N, 104°08′W), rock outcrops, 20 July 1973, *J. Ternier & S. Lamont 852* (SASK); SE of Cluff Lake, natural semi-vegetated, sand-blowout clearings in Jack Pine and Jack Pine-aspen forests, 15 June 1977, *V. L. Harms 23866,* 16 July 1977, *V. L. Harms N.A. Skoglund & R. Wright 24327* (SASK), open sandy roadside disturbance in Jack Pine forest, 19 July 1977, *V. L. Harms, N. A. Skoglund & R. Wright 24569* (SASK). The Cluff Lake collections represent a significant, approximately 880-km northwestward extension of the known range of this variety and species to northwestern Saskatchewan from central Manitoba, where it was previously reported by Scoggan (1957). This taxon seems unlikely to represent an introduction at Cluff Lake since it was well established in every small sand-blowout clearing visited, all of which appeared natural and thus far undisturbed by human activities. It should probably be looked for in similar sandy clearings throughout the northern boreal forest region of Saskatchewan.

Poa arctica R. Br.; Arctic Blue-grass.

McDonald Creek NE of Steephill Lake on Reindeer River (56°03′N, 103°02′W), well-drained open stream shore, 17 July 1974, *J. & J. Heilman 2303* (SASK); Cluff Lake, northeast end (58°19½′N, 109°34′W), natural and disturbed clearings in Jack Pine forests, 14 June 1977, *V. L. Harms 23815, 23854* (SASK). This circumpolar arctic-alpine species, which is known from across northern Canada and in the Rocky Mountains, occurs in western Alberta and northernmost Manitoba (Boivin 1967a), but was never previously recorded for Saskatchewan. However, *Poa lanata* Scribn. & Merr., which was collected by Raup (1936) at Lake Athabasca, may not be specifically distinct from *P. arctica.*

Polypogon monspeliensis (L.) Desf.; Rabbitfoot Beard Grass.

Batoche area, South Saskatchewan River, 9 mi [14.5 km] E and 2 mi [3.2 km] N of Rosthern (E ½ Sec. 6, T 43 N, R 1 W 3rd M), narrow flood plain and river bank, 2 September 1973, *N. A. Skoglund* (SASK). This introduced weedy grass species is widely naturalized in North America. It is known from various localities in southern Manitoba (Scoggan 1957) and in southeastern Alberta (Moss 1959). Its occurrence in Saskatchewan is thus not unexpected, but we are unaware of any previous collections from this province.

Trientalis europaea L. var. *arctica* (Fisch.) Ledeb; Arctic Starflower.

About 25 mi [40 km] SE of LaLoche, 1 mi [1.6 km] NW of Bear Creek, Mile 42 (Km 67) of Highway 155 (56°11′N, 109°09′W), mossy slough in Jack Pine forest, 16 June 1972, *V. L. Harms 18987* (SASK); near Wathaman River, Mile 65 [Km 104] of Highway 105 (57°05′N, 103°46′W), moist birch-alder-willow woods along stream, 30 June 1973, *J. Ternier & M. Jasieniuk 1664* (SASK). The North American variety of this Eurasian species has been recorded from Alaska, British Columbia, and Oregon, E to near Great Slave Lake in Mackenzie District, northwestern Alberta, and northern Idaho. The two new Saskatchewan records respectively represent about 480- and 800-km eastward extensions of the known range of the taxon.

180–315.

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Food of Ring-billed Gull Chicks at the Eastern Headland of the Toronto Outer Harbour in 1977

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Food was collected from young Ring-billed Gull (*Larus delawarensis*) chicks between 21 May and 5 July 1977 at the Toronto Outer Harbour in Lake Ontario. Fish, insects, and earthworms were the major foods, by volume, of Ring-billed Gull chicks. Insects decreased, earthworms increased, and fish did not vary over the season in the food samples. The composition of fishes and insects changed as the season progressed and those changes may reflect opportunistic feeding habits of the gulls. As the season progressed the chicks were fed more terrestrial organisms.

Key Words: *Larus delawarensis*, diet, Ontario, gull chicks, feeding habits, Great Lakes.

The population of Ring-billed Gulls on the Great Lakes has increased tremendously since the 1950s (Ludwig 1966, 1974; Blokpoel 1977). Numbers of nesting Ring-billed Gulls on the Eastern Headland (Leslie Spit) of the Toronto Outer Harbour, Lake Ontario (43°37′N, 79°21′W) increased from about 10 pairs in 1973 to about 10 000 pairs in 1976 (Blokpoel and Fetterolf 1978).

Food studies of Ring-billed Gulls on the prairies (Vermeer 1970) and in lakes Michigan and Huron (Ludwig 1966; Jarvis and Southern 1976) revealed major differences in food items. Those differences may mostly reflect food available to the birds in different habitats. At Leslie Spit we had the opportunity to study the seasonal variation in the diet of Ring-billed Gulls near a large urban area.

Methods and Materials

At Leslie Spit in western Lake Ontario we collected 147 food samples, each consisting of regurgitations from five Ring-billed Gull chicks that were less than 10 d old. Chicks were forced to regurgitate recently swallowed food by gently squeezing the food bolus from their proventriculus into their mouth. All samples were preserved in 95% ethanol.

Samples were collected on 23 d in the period 21 May to 5 July 1977. All samples used in this study were collected between 17:00 and 21:00 because a large proportion of chicks had food boluses during that time period. The food samples were grouped into three collection periods: early (21 May to 5 June), middle (6 June to 20 June), and late (21 June to 5 July).

Six categories of food were found in the samples: fish, arthropods (of which more than 99% were insects), earthworms, refuse, birds, and mammals. The contribution of each food category was assessed on a volume basis. The volume of each food category in each five-regurgitation sample was determined by water displacement in a 100-mL graduated cylinder using procedures described by Jarvis and Southern (1976). To allow for differences in total volume between five-regurgitation samples, the contribution of a food category was based on the percentage (by volume) of that food category in each sample, rather than the actual volume.

Most of the fish in the food samples was unidentifiable flesh; however, the large pieces were identified to species following Scott and Crossman (1973). To cope with the huge number of insects in the samples, all insects obtained in each collection period were pooled and thoroughly mixed. From each of those three groups of pooled specimens we took a large sample, here called a composite sample. The insects in each composite sample were identified to family or species by staff at the Biosystematics Research Institute, Agriculture Canada, Ottawa. The small mammals were identified to species following Banfield (1974).

Results

The mean percentage of each of the six food categories in the three time periods is shown in Table 1. Fish contributed about 50% by volume to the food samples in each time period. The mean percentage of arthropods in the samples decreased from 41% to 20% as the season progressed. The mean percentage of arthropods was significantly higher in the early period than in the middle and late periods. In contrast, the mean percentage of earthworms in the early period (8%) was significantly below that in the middle (23%) and late (28%) periods. The remaining three categories (refuse, mammal, and bird) were unimportant (only 1–6% combined) in all three time periods.

Although the percentage of fish in the food samples did not change as the season progressed, the species

TABLE 1—The mean percentage (± SE), by volume, of each food category found in samples each containing regurgitations from five Ring-billed Gull chicks at the Eastern Headland during three time periods[1] in 1977

	Early	Middle	Late
Number of 5-regurgitation samples	25	81	41
Fish	51 ± 6%	46 ± 3%	46 ± 4%
Arthropods	41 ± 5%	27 ± 3%[2]	20 ± 3%[3]
Earthworms	8 ± 3%	23 ± 3%[3]	28 ± 5%[3]
Refuse	< 1%	2 ± 1%	4 ± 2%
Mammals	0	1 ± 1%	2 ± 2%
Birds	0	< 1%	< 1%

[1]Early: 21 May–5 June; middle: 6–20 June; late 21 June–5 July.
[2]Significantly different from early period ($P < 0.05$, Mann-Whitney U-test).
[3]Significantly different from early period ($P < 0.01$, Mann-Whitney U-test).

composition changed (Table 2). The proportion of Alewife (*Alosa pseudoharengus*) in the early period was significantly lower than in the middle and late periods, whereas that of Rainbow Smelt (*Osmerus mordax*) was significantly higher in the early period than in the other two periods.

Insects comprised more than 99% of the individuals in the arthropod component in the diet of the chicks. The non-insect arthropods included spiders (Arachnida), centipedes (Chilopoda), millipedes (Diplopoda), and isopods (Crustacea). A large variety of insects was present in the food samples, including at least 95 families representing 13 orders of insects.

The family composition of the insects fed to young Ring-billed Gull chicks changed as the season progressed (Table 3). Midges (family Chironomidae) and leaf hoppers (family Cicadellidae) were the most common insects in the composite samples. Those two families comprised 51.8%, 60.2%, and 75.5% of the insects in the early, middle, and late periods, respectively. The percentage of midges in the insect samples decreased from 43.9% in the early period to 11.2% in the late period, whereas the percentage of leaf hoppers increased with progression of the season from 7.9% to 64.3%. Owing to their condition, the midges could not be identified to species. In the early period there were at least two species of leaf hoppers represented, of which *Macrostelles fascifrons complex* was the more common. At least nine species were present in the food samples collected during the middle period, when *Arthaldeus pascuellus* was the most numerous. In the late period *Anthysanus argentarius*, in the nymph stage, was the more numerous of the two leaf hopper species present.

Refuse in the food samples generally consisted of bread and sliced meat. The avian material consisted of small fragments of egg-shell and one fully developed gull embryo. Two Meadow Voles (*Microtus pennsylvanicus*) and one Deer Mouse (*Peromyscus maniculatus bairdii*) were the only mammals regurgitated.

The various food items in the samples were classified as associated with terrestrial or aquatic habitats. Thus fish and insects such as midges and mayflies were considered aquatic whereas earthworms and insects such as ground beetles and leaf hoppers were considered terrestrial. The mean percentage volume of the terrestrial and aquatic insects in each collection period was approximated by multiplying the proportion of those two groups in the composite sample by the mean percentage volume of insects in each collection period as given in Table 1. The mean percentage, by volume, of terrestrial organisms in the chick diet increased as the season progressed. Terrestrial food items in the early, middle, and late periods comprised 23%, 42%, and 51%, respectively, of the food volume.

TABLE 2—Species composition of fish found in regurgitations from Ring-billed Gull chicks at the Eastern Headland during three times periods[1] in 1977

	Early		Middle		Late	
	Number	%	Number	%	Number	%
Alewife, *Alosa pseudoharengus*	7	29.2	33[2]	64.7[2]	17	77.3[2]
Rainbow Smelt, *Osmerus mordax*	16	66.7	15[2]	29.4[2]	4	18.2[2]
Shiner, *Notropis* sp.	0	0.0	3	5.9	1	4.5
Yellow Perch, *Perca flavescens*	1	4.2	0	0.0	0	0.0
Total	24		51		22	

[1]Early: 21 May – 5 June; middle: 6–20 June; late: 21 June – 5 July.
[2]Significantly different from early period ($P<0.01$, χ^2-test).

TABLE 3—Family composition of insects found in regurgitations from Ring-billed Gull chicks at the Eastern Headland during three time periods[1] in 1977. Only those families which comprised 1% in at least one time period are listed

	Early		Middle		Late	
Order/Family	Number	%	Number	%	Number	%
Hemiptera						
Miridae	43	3.7	195	6.3	101	7.7
Nabidae	2	0.2	52	1.7	22	1.7
Homoptera						
Cicadellidae	91	7.9	883	28.7	839	64.3
Aphididae	25	2.2	141	4.6	42	3.2
Psyllidae	16	1.4	5	0.2	2	0.2
Neuroptera						
Hemerobiidae	21	1.8	22	0.7	0	0.0
Coleoptera						
Carabidae	23	2.0	33	1.1	17	1.3
Staphylinidae	6	0.5	71	2.3	3	0.2
Lepidoptera						
Geometridae	31	2.7	3	0.1	0	0.0
Diptera						
Chironomidae	508	43.9	968	31.5	146	11.2
Sphaeroceridae	71	6.1	59	1.9	5	0.4
Anthomyiidae	48	4.1	118	3.9	10	0.8
Tipulidae	25	2.2	54	1.8	17	1.3
Heleomyzidae	20	1.7	0	0.0	0	0.0
Ephydridae	19	1.6	9	0.3	4	0.3
Syrphidae	12	1.0	8	0.3	3	0.2
Hymenoptera						
Braconidae	28	2.4	64	2.1	3	0.2
Ichneumonidae	23	2.0	76	2.5	16	1.2
All other families	145	12.5	309	10.1	75	5.7
Total of insects in composite sample	1157		3070		1305	

[1]Early: 21 May – 5 June; middle: 6–20 June; late: 21 June – 5 July.

Discussion

Rainbow Smelt was the most common fish species regurgitated by Ring-billed Gull chicks during late May and early June, whereas Alewife predominated from mid-June to early July. Smelt congregate along shores to spawn shortly after ice breakup (March, April, or May depending upon location and weather) and return to deep water shortly after spawning (McKenzie 1964; Scott and Crossman 1973). Alewife, however, reach highest inshore concentrations about the middle of June in Lake Ontario and do not return to deeper waters until August (Graham 1956). Hence, the relative proportion of Alewife and Smelt in the diet of the chicks closely follows the relative abundance of the two fish species in shallow waters. This suggests opportunistic feeding on fishes.

The species composition of the insect sample also suggests opportunistic feeding behavior. Often an insect species would be very abundant in the food samples on a particular day and relatively rare 2 or 3 d later, suggesting that the gulls exploited a briefly abundant food source.

I. R. Kirkham (1977, unpublished report, Brock University, St. Catharines, Ontario) found that earthworms were frequently brought to Ring-billed Gull chicks at Gull Island in Lake Ontario following days of rain or high humidity. We were not able to correlate daily abundance of earthworms with weather parameters. This was expected, since in the Toronto area, parkland and golf courses are watered regularly, making earthworms available regardless of weather conditions.

Terrestrial organisms became more common in the food samples as the season progressed. This trend suggests either an increase in the availability of food inland or a decrease in the availability of aquatic food sources.

Ludwig (1966) found that Alewife was the most important item in the diet of Ring-billed Gulls, while Jarvis and Southern (1976) noted the importance of

insects and earthworms. Vermeer (1970) found that grain, insects, mice, and refuse were the most important food items during the breeding season on the prairies. Major differences in food items between the prairies and the Great Lakes may mainly reflect differences in food availability in completely different regions and suggest an opportunistic feeding strategy among Ring-billed Gulls. Differences between Great Lakes studies may reflect differences in food availability between localities and years as well as differences in collection procedures.

Acknowledgments

We thank the Toronto Harbour Commissioners for allowing us to work in the colony. R. J. Prins assisted in the field and the laboratory. B. L. Sack-Tina identified the insects with assistance of the Biosystematics Research Institute. D. B. Campbell helped identify the small mammals. J. E. Bryant and S. G. Curtis commented on drafts of the manuscript.

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Changes in Wolf Numbers, Algonquin Provincial Park, Ontario

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The wolf (*Canis lupus*) population of 1700 km² in central and southern Algonquin Park was surveyed eight times over an 11-yr period from 1965 to 1975. Added to five previously published surveys, changes in numbers can be viewed across 16 yr. Summer surveys employed a howling technique; winter surveys were from the air. Wolf packs were at a high (13 to 15) from 1958–1959 to 1961–1962. Most of the population was removed by trapping in 1964 and 1965. Wolves recovered to a high (12 packs) by 1971 and declined by approximately one-quarter between then and 1975. Over this total period, numbers of their principal prey, White-tailed Deer (*Odocoileus virginianus*) dropped drastically, as documented elsewhere. After 16 yr in which the wolf population was decimated at one point by trapping, and the major prey species crashed in numbers, the wolf population was no less than approximately 75% of its former larger size.

Key Words: Timber Wolf, Algonquin Park, population size, *Canis lupus*.

Eight surveys of wolves (*Canis lupus*) were conducted between 1965 and 1975 in a 1700-km² study area in central and southern Algonquin Provincial Park. Together with five surveys conducted in the preceding years (Pimlott et al. 1969), changes in numbers of wolves can be viewed across a 16-yr period. During that time, the wolf population was reduced drastically by trapping, and its major prey, White-tailed Deer (*Odocoileus virginianus*) declined (Pimlott et al. 1969; Voigt et al. 1976). The evidence presented here demonstrates the response of the wolf population to these contingencies.

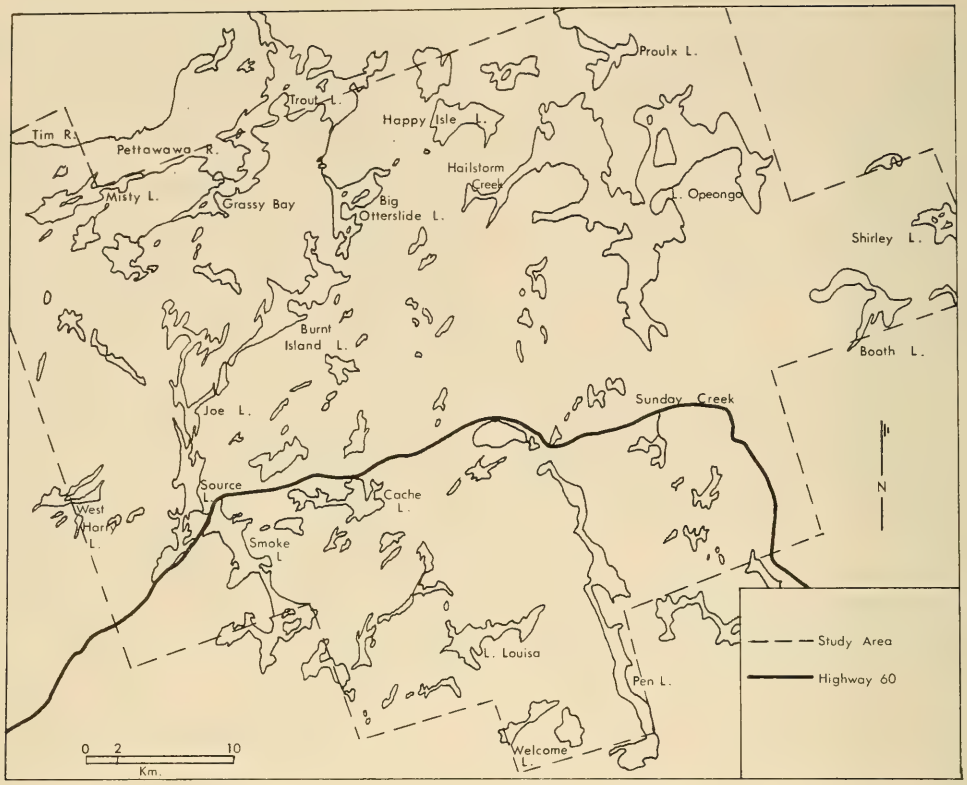

FIGURE 1. Wolf research study area, Algonquin Provincial Park, Ontario.

Study Area

Central and southern Algonquin Park is on the southern edge of the Canadian Shield, with rolling hills varying between 152 and 518 m elevation (Figure 1). Forests are ecotonal between the Boreal and Great Lakes – St. Lawrence Regions (Rowe 1972), and have been modified by a century and a half of logging. The three major mammalian herbivores are White-tailed Deer, Moose (*Alces alces*), and Beaver (*Castor canadensis*); these species make up more than 90% of wolf diets (Theberge et al. 1978). For a more complete description of the study area, see Pimlott et al. (1969).

Methods

Of eight surveys conducted between 1966 and 1975, four were winter aerial surveys and four were summer howling surveys. Winter surveys, conducted by Strickland, were flown in a Turbo Beaver aircraft at 200–400 m above the ground. Survey days were calm and cloudless; no snow had fallen for the preceding 20–48 h during which time wolf tracks were allowed to accumulate. At least three observers, including the pilot, systematically searched frozen lakes and rivers for tracks and wolves. The study area was completely covered in each survey, which lasted from 5.5 to 9.3 h. Wolf tracks were mapped from the point of discovery in both directions as far as possible before resuming the search, in order to minimize the possibility of counting wolves more than once.

Four summer howling surveys were conducted: throughout July and August by Theberge, in 1965, 1971, and 1974; by D. H. Pimlott and E. M. Addison in 1966. These surveys involved covering the study area at night by canoe, truck, or foot, and imitating wolf howls approximately every 1.6 km. Recordings and bearings were taken on responses. Numbers of packs, rather than numbers of wolves, were obtained from this technique. Because packs change their rendezvous sites approximately every 17 d (Joslin 1967), we re-surveyed as many of our routes as possible at approximately 2-wk intervals, in order to increase our chances of locating wolves that may have previously been out of hearing. We also re-visited packs numerous times after first hearing them, locating other packs in adjacent areas as quickly as possible, often the same night, to be certain we did not count the same pack more than once, or two packs as only one pack. Estimates of percent coverage of the

study area by the howling technique were made by projecting circles of 1.6-km radius from each howling point, a distance within which our howls and those of wolves were easily audible (determined by repeated examples) in the Algonquin environment.

Both the winter aerial surveys and summer howling surveys have limitations; they may miss packs or, less likely, they may allow packs to be counted more than once. These techniques have been discussed and evaluated elsewhere (Theberge and Falls 1967; Pimlott et al. 1969). When the results of the surveys are viewed as a series over the years, we believe a reasonably accurate picture of changes in numbers of wolves emerges. The same two survey techniques were used between 1958 and 1964 (three winter, two summer) as reported and evaluated by Pimlott et al. (1969). The accuracy of 1960 and 1961 summer howling surveys were verified by intensive and continuous winter aerial surveys in 1958–1959, and 1961–1962 (170 h), which yielded similar results. Expressions of density of wolves must be viewed for their comparative rather than absolute values, since some packs ranged beyond the boundaries of the study area.

Results and Discussion

The wolf population decreased from 13-15 packs (79+ individuals) in the 1958–1962 period (Pimlott et al. 1969) to only three or slightly more packs after trapping in 1965 (Figure 2). Although two packs disappeared (or merged with others) between summer 1960 and winter 1961–1962, the major portion of the decline occurred when a total of 77 wolves was trapped from the study area in winters 1963–1964, and 1964–1965 (Pimlott et al. 1969). This trapping must have removed close to the full population of the study area.

Despite this heavy trapping, in summer 1965 three packs were found in traditional pack locations, and in summer 1966 six packs (unpublished files, D. H. Pimlott, University of Toronto) (Table 1). These two surveys covered approximately 75% of the study area. Breeding nuclei may have been left for some packs, and/or immigration may have occurred.

At least part of the study area formerly occupied by wolves remained vacant for 4 y after trapping, that portion in the vicinity of Highway 60. From 1965 until 1968, the park's interpretive staff was unable to locate wolves in the highway region, despite considerable efforts each mid- to late summer. In the summer of 1969, however, wolves near the highway were being heard by, and reported to park personnel. A winter aerial survey in January 1971 revealed at least eight packs (46 wolves) in the total study area, and the following summer howling survey resulted in an estimate of 12 packs with certainty, and possibly two more, but we were unable to document the distinction of the latter two from nearby packs. Apparently, the

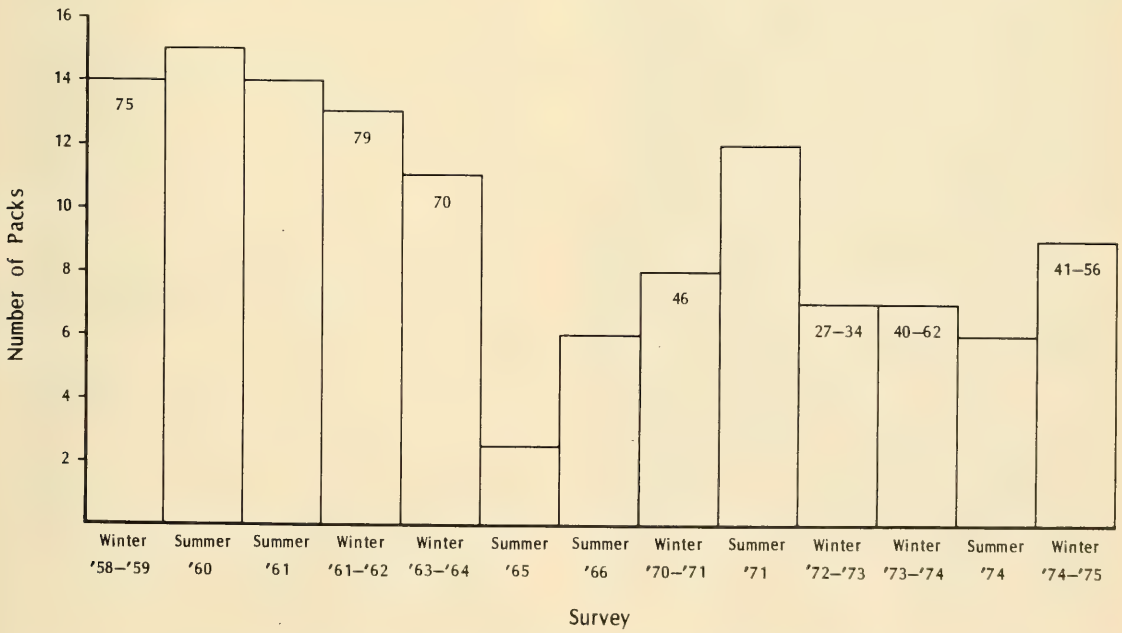

FIGURE 2. Number of wolf packs counted in surveys over 1700 km² in Algonquin Park, Ontario (includes data from Pimlott et al. 1969). Numbers of wolves appear, where an estimate was possible, at the top of bars.

TABLE 1—Season, extent of coverage, and results of wolf surveys in Algonquin Park, Ontario, 1965 to 1975

Year	Month	% Coverage	No. h flown	No. packs	No. individuals
1965	July–Aug.	75 (90)[1]	—	3	—
1966	July–Aug.	75	—	6	—
1971	Jan.	100	9.3	8	46
1971	July–Aug.	92 (62)	—	12	—
1973	Feb.	100	7.0	7	27–34
1974	Feb.	100	5.5	7	40–62
1974	July–Aug.	76 (91)	—	6	—
1975	March	100	9.0	9	41–50

[1]% with repeated coverage.

wolf population had almost or fully recovered from its close to total removal 7 yr previously.

After 1971, the wolf population declined slightly, possibly by one-quarter (Figure 2, Table 1). Winter aerial surveys produced best estimates of seven, seven, and nine packs; a summer survey in 1974, with comparable effort to that of 1971, produced only six packs (plus one later known to have been missed). The maximum estimate of number of individuals was 62, made in the 1973–1974 winter survey.

Between the early 1960s and early 1970s, White-tailed Deer, a major prey species, declined by 80–90% (Pimlott et al. 1969; Wilton 1970;[1] Wilton and Trod 1972[1]). Summer diets of wolves shifted from 80.5% White-tailed Deer in the years 1959–1965 (Pimlott et al. 1969) to 33% in 1972 (Voigt et al. 1976), and 28.9% between 1971 and 1974 (Theberge et al. 1978). Beaver, on the other hand, increased in abundance in Algonquin Park (Hall 1971) and in wolf diets from 7% to 55% (Voigt et al. 1976). Deer numbers were already low by 1971 when the wolf population was back to high numbers, indicating that the study area could continue to support a dense wolf population through the help of the buffer food species Beaver and Moose. Complete adjustments of the wolf population to changes in prey numbers may have, however, required more time; we noticed more single wolves, possibly an adjustment to hunting Beaver more efficiently, in summer 1974 (17 instances, although 11 may have been the same wolf) than in 1971 when none were noted.

All packs located in the summer of 1971 and 1974 had pups, as determined by hearing puppy howling. The presence of at least three or four pups in each pack (we could not determine whether more were present) indicated that sufficient recruitment was occurring to maintain a potentially increasing wolf population despite the slight decline in the size of the population.

[1]Reports on File, Ministry of Natural Resources, Pembroke, Ontario.

Acknowledgments

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A Gray Wolf (*Canis lupus columbianus*) and Stone Sheep (*Ovis dalli stonei*) Fatal Predator–Prey Encounter

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Child, Kenneth N., Kenneth K. Fujino, and Milton W. Warren. 1978. A Gray Wolf (*Canis lupus columbianus*) and Stone Sheep (*Ovis dalli stonei*) fatal predator–prey encounter. Canadian Field-Naturalist 92(4): 399–401.

A predator–prey encounter between a Gray Wolf (*Canis lupus columbianus*) and a band of Stone Sheep (*Ovis dalli stonei*) involved the wolf successfully chasing a ewe sheep and its lamb down a mountainside and then off a cliff to their deaths. Attempting to reach its victims, the wolf fell, probably accidentally, to its death. The strategy employed by the wolf to hunt these sheep suggests that surprise (or ambush) and downhill chases are the most successful hunting techniques used by wolves to kill sheep in the alpine.

Key Words: wolf, sheep, predation, Stone Sheep, Gray Wolf, predator strategy, prey, alpine.

Interactions between predators and their prey have been thoroughly studied and documented in the literature (Errington 1963; Mech 1970; Pimlott 1967). Although some authors have discussed the relative impacts of predator pressures on the status of prey populations (Mech 1970) and the selective nature of the act (Cowan 1947), few have had the opportunity to witness the behavioral interactions between a single predatory animal and its intended victim(s). But Dauphiné (1969), Gray (1970), Hornocker (1969), and Weaver and Mensch (1970) have provided some insights into the hunting strategies employed by a single predator when stalking and killing its prey.

Murie (1944) in his classical studies of Dall Sheep (*Ovis dalli dalli*) in Mount McKinley National Park, Alaska, documented many encounters between the McKinley sheep and the Gray Wolf (*Canis lupus pambasileus*). Unfortunately, many of his accounts were after-the-fact descriptions based mainly on track analyses and their subsequent interpretation. Geist (1971), on the other hand, stated that although wolves and sheep do interact, sheep have evolved anti-predator strategies to offset the predatory potentials of the wolf. Cowan (1947) studying predator status and activities in the Rocky Mountain national parks of Canada stated that wolves (*C. l. occidentalis*) and Bighorn Sheep (*O. canadensis*) did not interact very frequently as evidenced in the latter's often-observed disregard for the former's presence and as suggested by the low incidence of sheep remains in wolf scats. Except for Geist's studies on sheep behavior and evolution in British Columbia, little information is available that authenticates predation on Stone Sheep (*O. d. stonei*) by the Gray Wolf (*C. l. columbianus*). Interestingly however, Cowan (1947) and Geist (1971) independently concluded that both thinhorn and bighorn sheep have evolved anti-predator strategies by establishing range traditions in alpine habitats with ideal escape terrain, usually steep rocky cliffs or talus slopes. Murie (1944) further suggested that sheep generally escape predator attacks by either moving upslope ahead of the pursuing enemy or by maintaining an elevational advantage above the approaching predator.

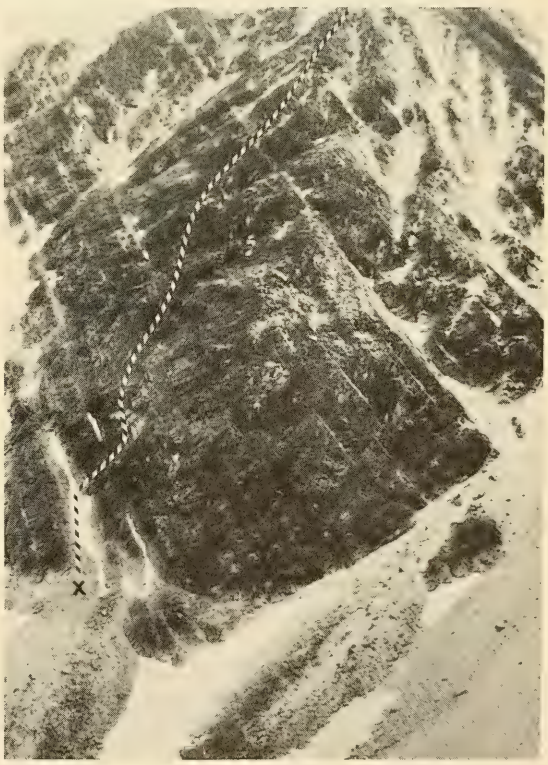

FIGURE 1. The general path followed by the thinhorn sheep and wolf during the chase down the mountain side. Carcasses were located amongst the rock scree at the base of the steep cliff positioned to the lower left of the photo. Photograph by K. Fujino.

FIGURE 2. The Gray Wolf and ewe Stone Sheep on the scree. Photograph by M. Warren.

On 20 July 1977 we observed a lone Gray Wolf (*Canis lupus columbianus*) interact with a band of Stone Sheep (*Ovis dalli stonei*) in the Finlay Range (57°N, 126°W) of the eastern Rocky Mountains, central British Columbia. The encounter was observed from a distance of approximately 0.8 km, using 8 × 30 binoculars and a 20 × 50 spotting scope.

At 17:43 a lone wolf was observed above the position of our campsite following a game trail along a glacial arrête heading westwards to a nearby mountain peak. The wolf stopped temporarily, surveyed our position and campsite for a few seconds, then continued to walk westwards following the height of land uphill towards an adjacent peak. At 17:52 the wolf was seen silhouetted against snow patches about 200 m from the summit. Briefly, the wolf looked down towards our position, then continued to climb the mountain eventually to disappear from our view amongst the rocky outcrops at the summit.

At 18:05 a band of six Stone Sheep (three ewes and three lambs) suddenly appeared running directly downslope from the outcrops within which the wolf had earlier disappeared. Shortly thereafter, the wolf was also spotted running down the same sharp inclines in hot pursuit of the sheep. The wolf was positioned approximately 40 m above and behind the sheep, and from our vantage point was seemingly gaining on the position of the six sheep below it. Near the 1370-m level, the sheep veered sharply from their flight path and headed into the rocky ledges as if to seek an alternate route to escape. The wolf halted as abruptly, paused for a few seconds, surveyed the escape of the sheep below it, then surprisingly reversed its direction of travel and moved upslope as if to regain its advantage above the sheep. For 3 min the wolf searched the area and occasionally looked downslope in the direction of the sheep, perhaps attempting to catch evidence of the exact position of the sheep below it. At 18:20 the wolf then moved downslope a distance of about 30 m and disappeared from our view amongst the crags. Suddenly, the wolf appeared, but this time chasing a single ewe and its lamb. At 18:22, the lamb, while running to escape the wolf, tumbled from the rocky ledges onto the rock scree below, a fall of approximately 75 m (see Figure 1). Within seconds, the ewe, in full gallop, fell as the lamb had over the same ledge. The wolf then approached the cliff, stopped momentarily, looked towards the position of the sheep, then turned about-face and moved upslope apparently in an attempt to seek an easy access to the carcasses.

We hurried to the scene in order to locate the sheep carcasses and to observe whether the wolf successfully retrieved its victims (Figure 1). Upon our arrival (after a 20-min walk), not two, but three carcasses lay still amongst the scree: the ewe, its lamb, and a wolf (Figure 2). From external markings and general body coloration, we concluded this to be the same wolf that

we had observed chasing the lamb and ewe earlier. We can only speculate that the wolf had also met its death by falling from the cliffs when it was attempting to gain access to the talus slopes and the sheep. At no time did we observe a second wolf. On the following day we surveyed the area by helicopter and since no other wolf was observed in the vicinity at that time, and because the three carcasses were still in place, our conclusion as to the identity of this wolf seems substantiated.

All three carcasses were examined and biological samples collected. The wolf was a young female and showed no evidence of having a recent litter. All claws and paw pads were heavily worn suggesting heavy travelling in rocky terrain. All teeth were in excellent shape.

The ewe and lamb also appeared to be in good health. No evidence of periodontal disease was noted in the ewe. The age of the ewe could not be determined from horn annuli as both had been broken during the fall. An incisor was extracted for age determination but unfortunately was lost.

Predators are reported to have evolved certain hunting strategies to take their victims. Cowan (1947) suggests that downhill chases and surprise (or ambush) are probably the two most successful strategies employed by wolves to kill sheep in the alpine. This encounter supports Cowan's conclusions and certainly verifies that wolves can and do, on occasion, singly employ such hunting techniques to stalk, chase, and kill thinhorn sheep. It remains a matter of speculation however, whether the bitch wolf had purposely driven the sheep over the cliff or whether accident had precipitated the deaths of all three participants in this predator–prey encounter. Certainly the actions of the wolf preceding its fall, would support the former explanation.

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Surfbirds in Ogilvie and Richardson Mountains, Yukon Territory

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Frisch, Robert. 1978. Surfbirds in Ogilvie and Richardson Mountains, Yukon Territory. Canadian Field-Naturalist 92(4): 401–403.

Despite a strong presumption (Godfrey 1966), indeed the claim (Taverner 1934), that the Surfbird, *Aphriza virgata,* breeds in northwestern Canada as well as in adjacent Alaska, proof of this had hitherto been lacking. This note reports the finding of a Surfbird chick in the Ogilvie Mountains, Yukon Territory, and presents evidence that the Surfbird is a regular summer resident of the southern Ogilvie and southern Richardson Mountains, Yukon Territory. As breeding records of the species were so far restricted to east-central Alaska (Mount McKinley Park, White Mountains in Tanana Hills, upper Fortymile River), this represents roughly a doubling of the known summer range. The data furthermore indicate that the Surfbird, though restricted in habitat, is by no means uncommon in the area under discussion, but may be considered a characteristic and regular member of the regional avifauna.

Habitat

Surfbirds were typically encountered on well-drained slopes and ridges in alpine tundra. In the Ogilvies, Surfbirds occurred in the 1300- to 1800-m zone (4000 to 5500 ft approximately); in the

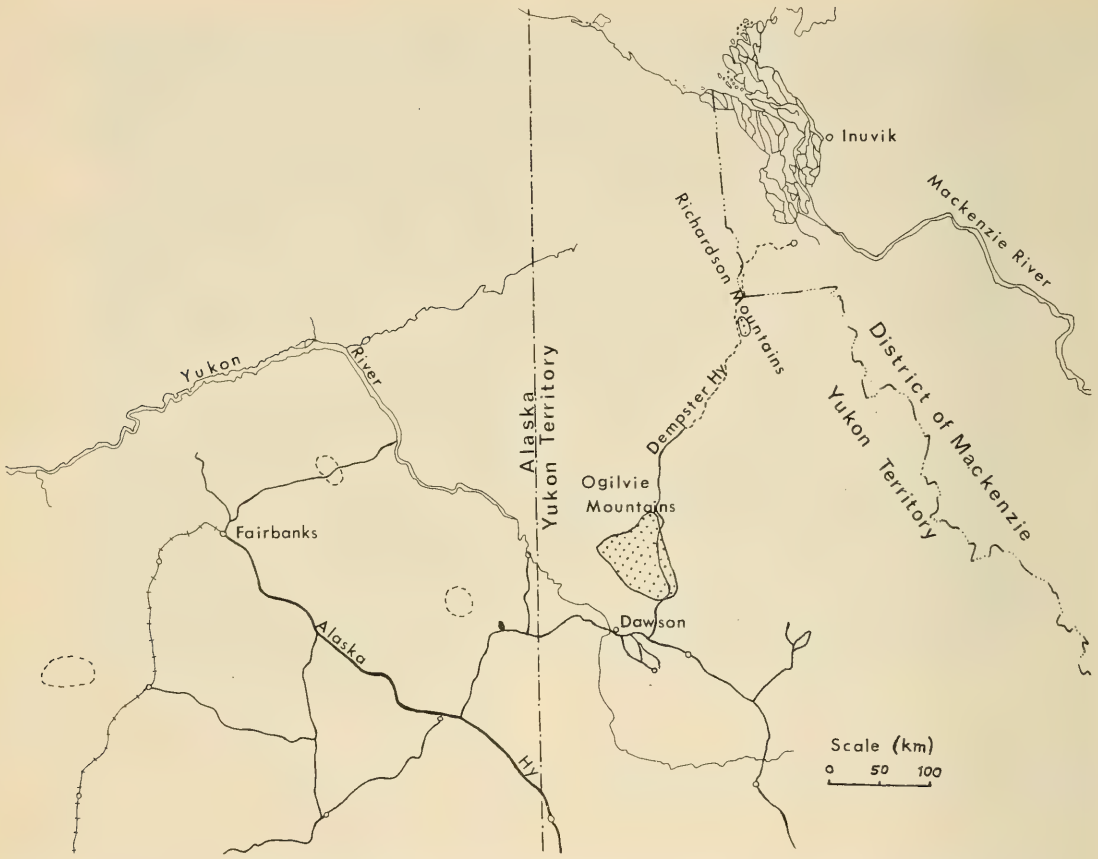

FIGURE 1. Central Yukon Territory and adjacent Alaska, showing areas of recent confirmed and probable breeding by Surfbirds (stippled) in relation to previous known breeding areas (broken outline).

Richardsons, habitat extended from 800 m to the regional summits at 1300 m (2500 to 4000 ft, approximately). Breeding sites, presumptive and confirmed, were all located on sparse mountain heath composed of lichen-moss-avens-heather interspersed with sedge and grass. Surfbirds were sometimes seen feeding on scree or rock-rubble, but mountain heath was the preferred habitat.

Dates, Locations, and Relative Abundance

The earliest seasonal observation of Surfbirds was 16 May 1977, when they had arrived in numbers at location 64°48′N, 138°10′W (none were present on 14 May). In 1976 Surfbirds were present at this location when it was first visited on 24 May. They were also noted there on 10 July 1975.

The latest seasonal observation, of a flock flying SW apparently on migration, was on 1 August 1974. Two locations where Surfbirds were seen repeatedly and/or exhibited behavior indicating breeding were visited respectively on 14, 15, and 17 July 1974, and on 29 July 1975; at neither location were Surfbirds noted on these occasions. Nor were Surfbirds seen on an excursion in the southern Richardson Mountains in late July 1975, where they were subsequently found to occur in early July 1977. These data suggest departure from breeding grounds by the latter part of July.

Over four seasons of observation in the Ogilvie Mountains (spring/summer 1974 to 1977), Surfbirds were recorded from a total of 11 locations (Figure 1). At seven of these they were observed repeatedly (for many consecutive days, in different months of the same year, or in different years), and/or exhibited behavior indicative of breeding (displays, alarm responses). A chick accompanied by a pair of adults was found at 64°50′N, 138°54′W on 4 July 1975. Its age was estimated at about a week (traces of pinfeathers on wing-stumps). Photos of adults and chick were obtained, and the identity of the birds was checked by W. E. Godfrey, National Museum of Natural Sciences.

On a brief visit to the southern Richardson

Mountains on 4 to 8 July 1977, Surfbirds were noted at four locations. At one of these (66°38′N, 136°12′W), an adult showed the alarm responses associated with the presence of young. In all likelihood, the Surfbird thus breeds in the Richardson as well as in the Ogilvie mountains (Figure 1).

In late June–early July 1976, when about a week was spent traversing Surfbird habitat in the southern Ogilvies, about 40 Surfbirds were counted (sightings and calls heard). Next to the Golden Plover, the species was the commonest non-passerine observed in the 1300+-m zone. These and other counts made over the seasons 1974 to 1977 indicate that a considerable population of Surfbirds summers in the southern Ogilvies. The sightings in the southern Richardsons, though limited to a small area, suggest that this applies to the latter region as well.

The failure to find a nest of the Surfbird, its far-ranging habits, and the persistent occurrence in the breeding season of apparently vagrant flocks, made it difficult to interpret such additional observations as the author was able to make. A meaningful account of the behavior of the Surfbird on its breeding grounds in Canada awaits closer study by qualified observers.

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Addendum

On 13 June 1978 I found the first Surfbird nest recorded for Canada in the southern Richardson Mountains (66°38′N, 136°15′W). It was an exposed scrape in mountain heath on an approximately 30° slope facing WNW at about 1100 m elevation. It contained two eggs which were later eaten by Arctic Ground Squirrels (*Spermophilus parryi*).

On 6 July 1978 on a rocky slope in similar terrain in the Richardson Mountains at 66°48′N, 136°14′W, Sharon Russell and Janet MacDonald found and photographed a Surfbird chick with two adults. This represents the northernmost breeding record to date for *Aphriza virgata*.

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Food Piracy by American Wigeons on American Coots

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Knapton, Richard W. and Brian Knudsen. 1978. Food piracy by American Wigeons on American Coots. Canadian Field-Naturalist 92(4): 403–404.

American Wigeon (*Anas americana*) steal food from other waterbirds, for example, Canvasback (*Aythya valisineria*), Redhead (*A. americana*), Lesser Scaup (*A. affinis*), and American Coot (*Fulica americana*) (Bent 1962, p. 95; Hellyer 1977). In this paper, we present data on coot–wigeon interactions and discuss the possible significance of robberies to each species.

During October in 1976 and 1977, we recorded interspecific interactions in mixed groups of coots and wigeons at Oak Hammock Marsh, Manitoba. We determined three methods of feeding by the wigeons: (*a*) A *robbery* occurred when a wigeon snatched food directly from the bill of a coot. In a typical robbery a wigeon swam to where a coot had dived and lunged at the coot as soon as it surfaced. (*b*) *Feeding pecks near a coot* occurred immediately after a coot surfaced, and presumably were directed toward pieces of vegetation that the coot had dislodged in its foraging dive or dropped subsequently. (*c*) An *independent feeding* was a motion in which a wigeon dipped its head below the surface.

Two feeding groups 40 m apart were observed in 1976. There were 77 wigeons and 27 coots in area A,

TABLE 1—Different feeding methods used by American Wigeons in different areas

Date	Area	Feeding method[1] a	b	c
1976	A	0	0	191
	B	72	43	0
1977	C	0	0	262
	D	41	29	0

[1] See text.

where the water was 40 cm deep and where filamentous algae occurred at the surface. There were 20 wigeons and 27 coots in area B, where the water was 42 cm deep and where the vegetation was only on the bottom. We recorded only independent feedings during 11 min of observation in area A, and only robberies and feeding pecks near coots, but no independent feedings during 20 min of observation in area B (Table 1). Thus the wigeons used different feeding methods in areas where food (aquatic vegetation) differed in its distribution (surface or bottom).

In 1977 we observed two groups in area C and three in area D, the two areas being over 1 km apart. The mean numbers of coots and wigeons during observations in area C were 10.0 and 11.8, respectively, and in area D were 15.3 and 24.0, respectively. We observed five wigeons in area C and six in area D; each wigeon was observed continuously for 5 min. In area C only independent feeding occurred, whereas in area D there were no independent feedings, and robberies constituted 59% of the total number of feedings (Table 1). Vegetation was at the surface in area C, and on the bottom in area D, and thus the results from 1977 are consistent with those of 1976. Furthermore, the three feeding methods were related to water depth, as the mean water depth in area C (48.0 cm) was significantly shallower than that in area D (61.7 cm) ($P<0.001$, Mann-Whitney U test).

Wigeons moved apparently randomly among the coots, taking advantage of a feeding or robbing opportunity when it arose. We observed only one instance of a wigeon driving another away from a coot that the first wigeon had been robbing, and no instances of splashing or calling by wigeons (c.f., Munro 1949, pp. 300–301).

The selective robbing of coots in water where the vegetation is on the bottom may allow wigeons to exploit a food resource which is either too deep for them to reach or which can be more efficiently acquired by robbing coots. This thief–victim relationship has been termed commensalism (Munro 1949), implying that a robbed coot suffers no penalty. Coots lose food for which they have expended energy, and therefore the process should be more properly termed piracy.

We thank R. M. Evans for providing equipment and valuable comments, and A. J. Erskine, L. Fredrickson, and two anonymous reviewers for their criticisms.

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News and Comment

Charles D. Bird Receives Award

On 10 January 1978 Charles D. Bird received the third annual Loran L. Goulden Memorial Award for outstanding contributions to the natural history of Alberta. Previous awards went to Dick Dekker and W. Ray Salt.

Although Charley Bird is widely known and respected as a botanist with special expertise as a bryologist, his interests range far beyond those of a Professor of Botany and Curator of the Herbarium at the University of Calgary and indeed embrace a wide range of subjects. For example, his work on the butterflies and skippers of Alberta forms the subject of several publications to date and a book is in preparation. Most naturalists know him as a well-rounded field-naturalist or ecologist.

Because he was convinced that far too little work was being done on basic distribution and natural history, he has channelled considerable effort in this direction. As well, he has encouraged amateur naturalists to add to our knowledge of both general distribution and natural history. His plant phenology study, a project of the Federation of Alberta Naturalists (FAN) is an excellent example of how amateur contributions can be coordinated into an important scientific effort. In addition to his own extensive contributions to the natural history of Alberta, he has encouraged and advised many others in the study of nature.

Charley's contributions to Alberta natural history, however, are not restricted to scientific efforts. He has strongly supported naturalist groups and, indeed, was instrumental in persuading the city of Calgary to set aside a major prairie area as a park. His expertise, reliance on baseline data, and experience in the field situation have been brought to bear on conservation issues and his work as an occasional consultant has helped mitigate environmental damage for some projects.

But perhaps his most important accomplishment to us has been his immeasurable influence in encouraging and stimulating others in the study of nature. Virginia Lang, Editor of the *Alberta Naturalist*, wrote, "Most people, I think, would feel over worked and derive satisfaction if they accomplished one-half of what Dr. Bird does. Yet, he never appears rushed or harried, and always finds time to help amateur naturalists . . . His office door has always been open regardless of whether or not you are one of his students. His suggestions, encouragement, enthusiasm and advice, always freely given, have no doubt resulted in the constructive channeling of much of the energy of amateur naturalists in Alberta."

Many permanent reminders of Charley's contributions to Alberta natural history are found in *The Calgary Field Naturalist* and the *Alberta Naturalist*. Furthermore, he was a member of the editorial committee of FAN from 1971 to 1974. And last but by no means least, he has served since 1974, and continues to serve, faithfully and competently as the Associate Editor of Botany for *The Canadian Field-Naturalist*.

Clearly Charley Bird is a most worthy recipient of the Loran L. Goulden Award and we are certainly pleased that he has thus been honored. Further details on his work in Alberta will be published in the September 1978 issue of the *Alberta Naturalist* 8(3) in an article written by Martin K. McNicholl (Beak Consultants Ltd., 3530 11A St., NE, Calgary, Alberta T2E 6M7). Most of the above account is based on this article, a copy of which was kindly supplied to us prior to its publication.

Revised Style Manual Available

Council of Biology Editors Style Manual: a guide for authors, editors, and publishers in the biological sciences. 4th edition. 1978. By CBE Style Manual Committee, Council of Biology Editors. 265 pp. $12.

This guide was prepared with the assistance of scientists, librarians, editors, and publishers. Substantially revised, this new edition contains valuable information on the planning and writing of an article, editorial review of the manuscript, reviewing proof and proof correction, indexing, general style conventions and style in special fields, abbreviations and symbols, word usage, and an annotated bibliography. The index has been greatly expanded to allow for more efficient use of the text.

The Council of Biology Editors Style Manual should be readily accessible to anyone involved in editing, scientific writing, and/or publishing. It is available from the American Institute of Biological Sciences, 1401 Wilson Blvd., Arlington, Virginia 22209.

Book Reviews

Zoology

Handbuch der Vögel Mitteleuropas, Band 6 und Band 7, Charadriiformes (1. und 2. Teil)

Edited by Urs N. Glutz von Blotzheim; prepared by Glutz von Blotzheim, Kurt M. Bauer, and Einhard Bezzel and many co-workers. 1975, 1977. Akademische Verlagsgesellschaft, Wiesbaden. 840 pp. and 894 pp., illus. 185 DM (North American price not given).

These weighty volumes dealing with the shorebirds are the latest in the German handbook series, which continues to appear at a rate of one volume every two years, a most impressive achievement. As with most non-passerines, about one-third of the species treated here occur more or less regularly in Canada. Our interest in these books is more than academic, especially since no North American handbook covering shorebirds has appeared in the last 40 years. The literature reviewed is stated to be complete to the end of 1974 and 1975, respectively, for these volumes, and there are a few 1976 references in volume 7. As with previous groups covered by more than one volume, there is a general section, at the start (of volume 6), including references not repeated in the species accounts. Treatment of the individual species varies, depending on their status in Middle Europe, with 50–65 pages for regular breeding species, 20–35 pages for arctic nesting birds that are regular migrants, and 7–17 pages for North American wanderers (which are much more regular in Europe than are European vagrants in America, owing to the prevailing winds which aid the eastward passage). The grouping of species will be unfamiliar except to shorebird specialists; after the plovers come the calidrine sandpipers (peeps) (also in volume 6), then the limosines (including woodcock, snipe, dowitchers, godwits, and curlews), the tringines ("shanks"), turnstone, phalaropes, stilt and avocet, and thick-knee, ending up with the oddments — courser, pratincoles, and sandgrouse (all in volume 7). The position of the turnstone in particular seems unusual.

For each species the material is treated under the following headings: general distribution, with discussion of geographic races where pertinent; field marks and description, the latter extremely detailed, including references to photographs showing species characteristics, measurements, and molt, with keys to sex or age classes in some cases, or to species distinctions in the case of dowitchers; voice, sometimes only given in words, but sometimes with several sonagrams; breeding range and migrations, with attempts to document population sizes in different breeding grounds and in migration or wintering areas, and details of phenology; biotope and breeding density; breeding biology, with age at maturity, details of eggs, and nesting success; behavior, with subsections on locomotion, preening, feeding, social and sexual activity, pair formation, aggression, response toward enemies, and brood care; and food, in breeding areas and elsewhere. Obviously, much less detail is provided for species that do not breed in the region treated, but some detail, with important references, appears under most headings even for these.

The emphasis given the various topics varies considerably, reflecting the available data for some species, but perhaps also following the interests and enthusiasms of the compilers. For example, under Dunlin with a total of 55 pages, migration receives 14 pages, behavior 6 pages, and description 6 pages (counting in separate sections under each of the two races in the region); but biotope receives only about 1½ pages, and details on feeding ecology (other than a listing of the forms taken in some areas) are almost lacking. Although key migration and wintering areas are often pinpointed, the details needed for (say) environmental impact statements are seldom there, often because they have never been worked out. Research on shorebird ecology is in its infancy, and these volumes will surely prove useful, both as compilations of information and of sources for more details in the planning of further research. Despite the slanted (to my eyes) treatment, they are obviously an enormous advance over previous handbooks on shorebirds, and they will prove valuable far beyond the bounds of Middle Europe. The scarcity of references to Canadian arctic studies surely indicates that most Canadians studying arctic birds have concentrated on other bird groups (e.g., geese or seabirds). It is unfortunate that the unfamiliar language and high price (at the present unfavorable exchange rate) of these sources will reduce their availability to would-be shorebird researchers in this country. Persons able to obtain and read them will find it well worth the cost and effort.

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A Guide to Bird-watching in Mallorca

By Eddie Watkinson. AB Grafisk Formgivning, Sweden. Available from M. Philbrick, P.O. Box 83, Vashon, Washington 98070, U.S.A. 56 pp. US $3.90 including postage and handling.

This readable and entertaining booklet gives the visitor to Mallorca a mass of useful information, not only on where to find birds there, but on local customs, facilities, laws, language, and a host of other details. Watkinson is an English businessman who retired to the island, and these parts of his text are primarily directed at an English audience but it is all readily digestible by the North American reader as well.

Mallorca is the largest of the Balearic Islands, off the coast of Spain in the western Mediterranean. It is a popular European holiday destination, but because it is a large island it offers excellent birding as well. Because it is an island it lacks many species that can be found in the Spanish mainland, but attracts migrants and pelagic species, and is *the* place to see Eleanora's Falcons.

Watkinson's Guide has many large clear maps and explicit directions, as well as excellent hints on how to find particular species. One caution: on page 2, he refers to the "recommended Puerto Pollensa–Can Picafort area" as *the* region to stay, but you will search for these places in vain on the adjacent map. The area, however, appears to be the one shown on the inset map on p. 19, although I was unable to locate Can Picafort.

If a European trip appeals to you and you have time to visit the Balearics, then be sure to get this book. In any case, the general sections are quite interesting even for the would-be visitor to the Spanish mainland.

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A Guide to the Birds of Panama

By Robert S. Ridgely. Illustrated by John A. Gwynne, Jr. 1976. Princeton University Press, Princeton, New Jersey. xv + 394 pp., + 32 plates. US $15.00.

The lack of good guides to the birds of Central and South America has received encouraging attention in recent years. The appearance of Ridgley's guide to the birds of Panama now gives visitors to this relatively accessible part of Central America a well illustrated and comprehensive guide to draw on.

The book took Ridgely and Gwynne five years to complete, and deals with the 883 species that have been recorded in Panama over the last century. Of these, 529 are illustrated in color (not almost 650 as suggested on the dust jacket) and almost another 100 in black-and-white text illustrations. More important than these statistics, however, are the number of species not illustrated at all, and apart from birds well covered in the North American guides only some 40 or 50 species fall into this category, and none of these omissions are likely to hinder the observer seriously: they are mostly birds that are rare, and often either relatively unmistakable where they occur or, alternatively, so similar to some other species that a plate is not likely to help much.

The color illustrations are grouped together in 32 plates in the center of the book. Each species depicted is named on the facing page, with a terse note on the key field characteristics and a reference to the appropriate page in the text. The plates, while not great bird art, are adequate and seem accurate, as does the color reproduction. In some cases dissimilar immature or female plumages are not shown, only mentioned in the text, but where females have significantly different plumages they are illustrated.

The text is organized into five sections with two appendices. The main descriptive text is preceded by chapters on Climate, Migration and Local Movements, Conservation, and a useful section on the plan of the book. The appendices list additional species in "Southern Middle America" and give directions for finding birds in Panama. The two endpapers have maps of Panama as a whole and of the Canal Zone area. There is also a two-page bibliography and an index to the species discussed.

The supporting chapters are valuable elements in the book: for example, the section on migration has three tables showing regular and pelagic migrants, and casual visitants, as well as a discussion on the local movements of Panamanian species (note on the tables that Lincoln's Sparrow and Least Storm-Petrel seem to have been interchanged in Tables IV and V). Appendix 1 gives a list of resident species not known to occur in Panama but recorded in the area north from Costa Rica to Honduras. Distributional notes are given for each, and, for species not included in Peterson and Chalif's *A Field Guide to Mexican Birds*, brief descriptive notes. Hence the book is of value for the southern Central American area as a whole, and not only in Panama itself.

Equally valuable is the appendix on Finding Birds

in Panama. This 15-page section may seem to compare poorly with Edwards and Loftin's guide of the same name, where 60 pages are devoted to the area. Almost a third of the latter, however, is devoted to bird lists, and in fact Ridgley's work represents a valuable updating and revision of the 1971 Edwards guide.

But the bulk of the book is the systematic list of species, and this is a satisfying treatment, following the now-traditional pattern for each species of Description-Similar Species-Status, but with the addition of sections on Habits and Range, the latter covering the range outside Panama and the occasional Note, usually referring to nomenclature. The habits section is particularly useful in giving an observer unfamiliar with the species some idea of what to look for. Other helpful elements in the species' treatments are the italicization of diagnostic features, and the use of the first sentences of the accounts as a "warning" where necessary: as, for example, "Only known from Darien."

Ridgely indicates he has followed Eisenmann and de Schauensee in English nomenclature and he has adopted a middle-of-the-road approach to taxonomy, not only because he "makes no pretense of being a taxonomist" but because the character of the book makes taxonomic innovations inappropriate.

In summary, *A Guide to the Birds of Panama* represents a major contribution to the available literature on Central American birds, and is essential for anyone planning a visit to see birds in Panama or working with Panamanian avifauna.

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North American Bird Songs — a world of music

By Poul Bondesen. 1977. Scandinavian Science Press Ltd., Klampenborg, Denmark. 254 pp., illus. US $15.50.

Recent widespread interest in using bird song as a major census tool and the recent proliferation of field guides combine to make the appearance of a guide to bird song seem inevitable.

In a short preface, the author outlines his experience in North America, crediting T. F. McIlwraith of Toronto with stimulating his interest in bird song in 1949.

Bondesen uses a series of short introductory chapters to discuss the concept and biology of bird song, to outline behavior associated with song, and to describe methods of recording and analyzing bird song. Musical and poetic interpretations of bird song are included in a short chapter. In general, the author appears to be up to date and accurate in these chapters. Persons wishing to record birds, however, would do better to read articles in recent issues of *American Birds*, and several books on bird song provide better (though less concise) introductions to the biology of bird song. Poor English hinders the reader throughout these chapters. A very useful feature following the introductory chapters is a chronological list of "grammophone" records (actually including tapes) of North American bird songs.

The bulk of the book consists of a "key" to songs of North American birds. In fact, only passerines are included, with such "true" (vocal) songsters as Blue Grouse, doves, cuckoos, caprimulgids, and Anna's Hummingbird excluded. Most, if not all, native North American passerines are included, as well as such long established exotics as European Skylark, Starling, the two ploceids, and European Goldfinch. The Crested Myna is, however, missing.

The key is divided into three major groups, referred to as "starling," "warbler," and "thrush" groups. Each group is subdivided several times, with an introductory outline to the major divisions. Having followed the key as far as these major divisions, one must hunt through following pages for further alternatives. Species are arranged according to various features of the song, so that taxonomically related species may be far removed in the book, and species with more than one song may appear twice. In such cases cross reference is made to other pages on which the species occurs. A sonagram accompanies the description of most (not all) songs, as well as details of behavior and habitat, with citations to previous descriptions of the song. A few details are far removed from the subject of the book, such as the number of hosts of the Brown-headed Cowbird.

The key is followed by a glossary (termed "vocabulary"), a "bibliography," a list of literature cited, a list of sources of songs used for the sonagrams (many recordings by W. W. H. Gunn of Canada), and an index.

In general, the book is relatively free of factual errors. Bondesen's use of the term "subsong" is a bit too dogmatic, without referring to other uses of this term. His definition of true song as "vocal music" is not very helpful. His statement that Black-billed Magpies are "decidedly quieter" than most corvids

would surely be challenged in Edmonton! And the description of the song of the Yellow-headed Blackbird as "sounds like vomiting" is overly dramatic.

The "bibliography" is a short list of selected regional bird books, life history works, and some books on song. The important books on bird song by Armstrong, Hinde, and Thorpe are not included, although the latter two appear in the literature cited.

The nomenclature is outdated in places, with such names as Purple Grackle and Blue-headed Vireo, although some of these (e.g., Bicknell's Thrush) are used to distinguish races with distinct songs. *Tyrannus verticalis* is described under its old name of Arkansas Kingbird, with Western Kingbird used to refer to a race of the Tropical Kingbird.

The most serious fault of the book is the poor translation into English, resulting in numerous examples of misspellings, words run together, strange expressions (such as "told to be" for "said to be"), strange words ("thruberries" for shruberry"), and strange sentences (such as "By attacking habit: if the strange[r] flees, it's a male."). One can usually understand the meaning intended by these strange sentences, but a few require several readings. Perhaps the most amusing sentence (p. 29) describes P. P. Kellogg (to whom the book is dedicated) as using a parabolic reflector to catch flying birds.

In summary, Bondesen has provided a useful compilation of sonagrams and references on songs of North American passerines. As a key, the book is adequate but tedious. For an introduction to bird song, the reader is advised to look elsewhere.

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Birds and Marine Mammals: The Beaufort Sea and the search for oil

By Donald A. Blood, edited by Brian D. Smiley. 1977. Department of Fisheries and the Environment, Sidney, British Columbia. 124 pp., illus. Paper, $2.50.

This paperback highlights information from 8 of the 45 publications in the Beaufort Sea Project Technical Report Series. The publication provides a general overview of petroleum exploration in the Beaufort Sea region and its potential threat to arctic ecosystems. It is intended for public use and therefore is of limited value to researchers.

The author generally covers aspects of the physical environment, Beaufort Sea wildlife (e.g., marine life, mammals and birds), and wildlife and oil. About one half of the book deals specifically with birds and marine mammals, each species account varying considerably from the others in content. The remaining 40 percent covers an assortment of topics, from climate to ecological relationships and wildlife sanctuaries in the Beaufort Sea.

The real value of this book lies in the descriptions of the climate and oceanography of the Beaufort Sea and in the discussion of environmental pollution as it affects the ecological relationships of wildlife in the area. Also, most of the figures beautifully condense technical data to show such things as migration routes, abundance and concentrations, and major breeding areas for important species of marine birds and mammals.

There are, however, several disappointments in the book. The line drawings, if they are to be used for identification, are poor; if to enhance the book, they are only fair. The distribution maps for select species add little to the publication since they are available, and have been copied directly, from the major Canadian works on birds (Godfrey) and mammals (Banfield). Some standard references, of use to the reader, have been omitted, for example "Birds of Arctic Alaska" by A. M. Bailey, "The Mackenzie Delta Area, N.W.T.," by J. R. MacKay, and "A Biological Investigation of the Athabasca — Mackenzie Region" by E. A. Preble. Finally the book suffers occasionally from the lack of additional information which would have required a monumental effort to extract from various consultant reports. For example, the author states (page 45) "that . . . trumpeter swan . . . does not nest in the Canadian Arctic." During the summer of 1972, however, a family of Trumpeter Swans (with downy young) was located near the northwestern corner of the Mackenzie Delta (Environment Protection Board, Winnipeg).

In summary, the book is a useful introduction for those interested in the problems of wildlife and oil, and also the economic values of sensitive species in the Beaufort Sea area.

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Précis de Zoologie: vertébrés. 2. Reproduction, biologie, évolution et systématique. Agnathes, poissons, amphibiens et reptiles

By Pierre-P. Grassé. 1976. (Masson, Paris, New York, Barcelone, Milan. 2nd ed. 464 pp., illus. (no price given).

This is the middle volume in a series of three, the first being on invertebrates, the third on birds and mammals. They are intended to be compact up-to-date texts for students and laymen, especially those interested in environmental biology.

The first 130 pages discusses embryology of all the classes of vertebrates, not just fish, amphibians, and reptiles. The tone is descriptive without theoretical and experimental discussions or descriptions of abnormalities. The sections on fertilization, cleavage, and gastrulation are well written and current and that on embryonic membranes and placentation is very thorough. The origin of germ cells and development of gonads are treated in depth. But here detailed description stops, and development of such organs as the eye, ear, heart, and kidneys is described sketchily, if at all.

In the second part the classes of vertebrates are discussed one by one from the lampreys up through the reptiles. The organization of the material is loose, but includes evolution, anatomy, physiology, reproductive biology, and descriptions of some families in each group.

The remainder of the book is divided between fishes (110 pages), amphibians (77 pages), and reptiles (113 pages). Aside from five citations for consultation, there is no list of references. A detailed index is provided.

The section on fishes is a mixture of old and new. Much of the classification evidently derives from the 1958 Traité de Zoologie, Tome 13. Unfortunately the order Tetraodontiformes is still retained amongst the soft-rayed fishes between the Clupeiformes and the Cypriniformes, rather than amongst the spiny-rayed fishes, despite considerable evidence to the contrary. The Cyprinodontiformes and Beloniformes are not united under the Atheriniformes, nor are the Gonorhynchiformes recognized with the Cypriniformes in a superorder Ostariophysi, although there is good support for such a grouping. It would have been preferable to place the Acanthodii nearer the Elasmobranchii and Osteichthyes, rather than before the Placodermi to express better their close relationship with the latter. In short, the recent advances in the higher classification of fishes have not been reflected in classification used.

On the other hand, new information on the pseudobranch (up to 1975) and on electroreceptors (1974) has been incorporated. P.W. Webb's work (1975. Bulletin of the Fisheries Research Board of Canada Number 190) was probably not available at the cut-off date but might otherwise have been referred to in the section on locomotion. The coelacanth, *Latimeria chalumnae*, is treated in interesting detail and provides an excellent summary of anatomical information.

The small type and narrow page margins permit a great deal of information to be packed into some 450 pages. The drawings, editing, and binding are up to the usual high standards of Masson. We personally would prefer matte to the glossy paper which is hard on the eyes.

Although not an exhaustive treatment of reproduction, biology, evolution, and systematics of vertebrates the volume does provide a useful summary in a concise, clear, and well-illustrated format.

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Optical Signals. Animal communication and light

By Jack P. Hailman. 1977. Indiana University Press, Bloomington. (Canadian distributor, Fitzhenry and Whiteside, Don Mills.) 362 pp., illus. $18.

This attractive book by Professor Hailman of the University of Wisconsin is a good example of the new type of scientific writing which can only, by its nature, attract a small readership, but which deserves to be published. It is handsomely bound, but printed on inexpensive paper and with unjustified typeset, presumably from camera-ready copy.

In the Foreword, Thomas Sebeok feels that this book, the first of its kind in the field, will become "an incitement as well as a model for comparable works" in other fields of animal behavior. I hope so. It does a

fine job of elucidating why optical signals in the animal world have the characteristics they do. The subject matter is difficult, but ordered as well as it can be: each chapter begins with a chart explaining how it is organized, and ends with an overview of what has been discussed. Mathematical treatment has been introduced where necessary, but it has been kept as simple and as short as possible. The author lightens the text with personal observations, by including applicable literary quotations, and by using clear line-drawings to illustrate his points. The text is fully referenced with 15 pages of literature cited, and contains separate indexes for people, animals, and subjects.

A brief look at what each chapter contains will give a good idea of the scope of this book. Chapters 1 to 3 form a solid basis for the remainder of the work, dealing with the principles followed, the nature of communication in general, and the pertinent features of physical optics. Chapter 4 shows that an animal sending out information can do so in a variety of ways, not only by physical movements (locomotion, display), but by using photic organs (fireflies, deep-sea fish), and by reflecting light selectively from colored parts of the body using biochromes, schemochromes, and color change. The receiver uses its eyes and nervous system to extract information from the optical signals sent to it (Chapter 5). The receiver imposes limitations on what it receives, and therefore affects what message is sent: there is no point in using an assortment of colors in communication if the recipient is color-blind.

Chapter 6 deals with specialized signals of deception or misinformation. Signals that confuse a predator include the suppression of one's shadow or one's outline, imitating the environment or another species (mimicry), feigning injury or death (e.g., killdeer parent, opossum), and sending signals which are ambiguous (the spot on a butterfly's wing resembling the eye of a much larger animal). Chapter 7 is addressed to environmental "noise" and the problem of how one can be conspicuous to nearby conspecifics but at the same time inconspicuous to predators farther away. Signals can be affected by material obstructions such as fog, turbidity, or vegetation between sender and receiver, or by the difficulty of distinguishing a signal from its optical background. Chapter 8 gives many examples of communication involving all aspects of social behavior, from threat and appeasement to reproduction. Chapter 9 concludes the book with a discussion of problems that Hailman's analysis has raised and prospects for future work on communication. Many readers may be somewhat overwhelmed by the variety of topics discussed in this book, but it will surely trigger new ideas and perceptions in their minds.

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Working for Wildlife — The beginning of preservation in Canada

By Janet Green Foster. 1978. University of Toronto Press, Toronto. 283 pp., illus. $19.95.

Working for Wildlife is, for two reasons, a suitable title for this scholarly, well-documented book: the subject is a historical account of those who helped pass laws that would preserve wildlife in Canada (it is based on the author's 1971 doctoral thesis in history for York University); and it reflects the valuable service Dr. Foster herself has done in compiling such an important basic work on conservation.

A century ago Canadian wildlife was in jeopardy primarily because it was an era of human exploitation. One tourist who travelled west by rail in 1888 was not troubled by the heaps everywhere of buffalo bones. The buffalo symbolized only a land that was a "wild and useless waste," while the train's whistle meant "education and religion, law and order, and best of all, the grass supporting men, women, and children, instead of herds of beasts." His attitude reflected that of most nineteenth-century North Americans.

Foster also underlines the myth of superabundance of animals in North America which had not yet died, despite the near-extinction of the Passenger Pigeon. One man shot six Caribou in the hills near Quebec City to see how well the sight on his new rifle was working: a few Caribou did not matter when there were myriads more in the north. Other threats to wildlife were an uninhabited frontier where animals could be decimated with few people knowing about it; a lack of knowledge about wildlife even among the civil servants who worked for it (only Gordon Hewitt was a trained zoologist); and the division of power between federal and provincial governments.

The reasons why wildlife was not exterminated wholesale were not aesthetic or sentimental, but rather utilitarian. Primarily wildlife was a source of food. In the Northwest animals were afforded some

government protection in 1894 because if the slaughter of animals had continued, the native people would "either starve to death or make their way out to the settled parts and become wards of the country." As well, animals were eventually thought worthy of preservation because of recreational hunting and tourist revenues. The first national park reserve of Banff Hot Springs was established in 1885 not primarily to protect wildlife, but to promote the newly-built and debt-ridden Canadian Pacific Railway and to bring in tourist dollars.

The animals given sanctuary in the Rocky Mountains thrived, proving such an attraction that for the first time such natural resources began to seem important. The future of individual species became worth considering. The plains buffalo was preserved when the Canadian government bought the last large herd in North America from a herdsman in Montana. The 703 animals were very popular as a tourist attraction when they were all finally moved in 1911 to the newly created Buffalo National Park near Wainwright, Alberta. The Wood Buffalo Park came into existence shortly afterwards for the woodland race of Bison.

The author also discusses other animals that were rescued from extermination. For example when Pronghorn neared extinction, three small prairie areas were given Dominion Park status in 1922 so that the antelope in them might be preserved. This protection was so effective that before long antelope were restocking their former range and the parks could be abolished. The protection of the Pronghorn was no longer necessary.

The most remarkable step forward in legislation affecting wildlife was the passing of the Migratory Birds Convention Act in 1917 — not, of course, because birds *should* be preserved, but because insectivorous birds were important to agriculture. This act ensured not only that United States and Canada would work together to preserve migratory species that ranged throughout North America, but that the provinces also would cooperate, even though they were then, as now, very jealous of their constitutional rights. (This cooperation was severely strained when British Columbia at first refused to stop hunting endangered species of waterfowl and to abandon spring hunting.)

At this time seabirds on the east coast were among those which desperately needed protection. (Audubon had noted in 1833 that one party of four men took 400,000 eggs in a two-month period to sell in Halifax at 25¢ a dozen.) In 1914 the Department of Marine and Fisheries issued an order that all Double-crested Cormorant nests on Percé Rock be destroyed, because these birds were thought (wrongly) to prey on young salmon fry. When an ornithologist protested, he was told cormorants were "of little value, either directly or indirectly." Fortunately sanity prevailed and in 1919 Bonaventure Cliffs, Bird Rocks, and Percé Rock were declared federal bird sanctuaries.

By 1922 the first phase of wildlife conservation in Canada was complete. The federal and provincial governments were meeting to discuss common problems, and Canadians, albeit much later than Americans, were becoming aware that wildlife, more than any other natural resource, was sensitive to human interference and well worth protecting. A few dedicated civil servants had accomplished a great deal in only a few decades. Dr. Foster is to be commended for undertaking this thorough and timely historical review of their work.

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BOTANY

Modern Methods in Forest Genetics

Edited by J. P. Miksche. 1976. Springer-Verlag, New York. 288 pp. US $23.80.

Forest geneticists and tree breeders work with wild organisms that have only a short history of genetic studies and cannot be easily handled in the laboratory or field. Unlike agricultural crop breeders, tree breeders must rely largely on experiments based on a minimum of cultivation and protection, which may last several decades until tested populations reach maturity and provide meaningful estimates. No wonder, then, that they are endeavoring to apply biochemical and physiological methods which reveal something of the intricacies of genetic structure at an early stage, for example, after isoenzyme analysis.

These and other methods, however, are not easily applied without a strong biochemical background and specialization in certain analytical techniques. Furthermore, sampling and testing must be adjusted to the requirements of the quantitative geneticist.

To assist its members with these problems, the Working Party on Biochemical Genetics of the International Union of Forest Research Organizations conducted a workshop at the University of Göttingen, Germany, 5–28 July 1973. The organizers, Professors Klaus Stern, Göttingen, and Robert G. Stanley, University of Florida, both died within little more than one year of the workshop. The papers were then edited by Dr. Jerome P. Miksche, U.S. Forest Service.

There are 13 Chapters: 1, Optical techniques for measuring DNA quantity (G. P. Berlyn and R. A. Cecich); 2, Nucleic acid extraction, purification, reannealing and hybridization methods (R. B. Hall, J. P. Miksche, and K. M. Hansen); 3, Gel electrophoresis of proteins and enzymes (P. P. Feret and F. Bergmann); 4, Extraction and analysis of free and protein-bound amino acids from Norway spruce foliage (J. Lunderstädt); 5, Photosynthesis, respiration, and dry matter production (W. Zelawski and R. B. Walker); 6, Analyses of monoterpenes of conifers by gas-liquid chromatography (A. E. Squillace); 7, Isolation and analysis of plant phenolics from foliage in relation to species characterization and to resistance against insects and pathogens (J. Lunderstädt); 8, Mineral analyses (F. H. Evers and W. Bücking); 9, Pollution responses (K. F. Jensen, L. S. Dochinger, B. R. Roberts, and A. M. Townsend); 10, Indirect selection for improvement of desired traits (K. von Weissenberg); 11, Pollen handling in forest genetics, with special reference to incompatibility (E. G. Kirby and R. G. Stanley); 12, Tissue culture of trees (L. Winton and O. Huhtinen); 13, Manipulation of flowering in conifers through the use of plant hormones (R.P. Pharis).

One must admit that the selection of subjects is a "mixed bag," but it is related to primary current concerns in the field. Some of these fall into the "pure research" category, others are related to breeding programs, although applications may not be simple or direct. Most of the authors are well known for their contributions in their field of specialty and have done a good job of synthesizing widely scattered information. The editor and also the publisher deserve a great deal of credit for welding language and illustrations from authors in five countries into a clear, easily accessible publication. Teachers, graduate students, and research workers in biological fields will value this book in their library.

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The illustrated Flora of Illinois. Sedges: *Cyperus* to *Scleria*

By Robert H. Mohlenbrock. 1976. Southern Illinois University Press, Carbondale. 192 pp., illus. US $15.

The publication of this volume constitutes another step forward towards the completion of a series of floristic works on the flora of Illinois which will probably run to many volumes. Although there is an overall plan to the work designed to cover every group of plants from algae to vascular plants, individual volumes will appear as they are completed, rather than follow a schedule. An advisory board was set up in 1964 to make suggestions for the content of each volume during its preparation.

This volume is the sixth to appear and is the first of two treatments on the sedges. The second will contain only the large genus *Carex*. Those that have already appeared are as follows:

Ferns — 1967
Flowering Plants. Flowering Rush to Rushes — 1970
Flowering Plants — Lilies to Orchids — 1970
Grasses. *Bromus* to *Paspalum* — 1972
Grasses. *Panicum* to *Danthonia* — 1973

This list is presented here for those who wish to obtain the complete set. All volumes, except the Ferns, are listed in the literature cited. Why the Fern book is omitted is not clear.

In this book, assistance in the preparation of the text of *Eleocharis* was obtained from Donald J. Drapalik (pp. 59–91), but the remainder was presumably written by the editor/author of the series, Robert H. Mohlenbrock. As he had already treated the group in papers cited, of course the work here was made easier.

The plan of the volume follows very much that of the earlier ones: there is an illustrated section on morphology, an all too brief discussion of family relationships, a paragraph on how to identify a sedge, followed by a very useful illustrated key to the genera of Cyperaceae which should do a great deal for both the beginner and the more well-informed towards clarifying the differences among them. There is a very curious repetition of the family description on pages 10 and 15 which is puzzling; these descriptions are not identical and after reading and comparing them, I

must conclude that either the first is intended to be a general one for the family and the second to the family as it occurs in Illinois, or else it is a manuscript error that managed to reach the printer without being detected.

The second family description is followed by short tribal descriptions (there are 4 tribes of the family in Illinois) and each genus within the tribe is described and followed by a key to the contained species. For each species, principal synonymy, a description, habitat data, general range, and Illinois range are given. The maps for each species are county dot maps without actual locations, in the manner of Deam's *Flora of Indiana.* Maps are supplied even for forms, an unnecessary exercise, for one may question whether even a species map contributes much in a flora of such a relatively small region as Illinois.

Species illustrations usually occupy a full page but at times less, in an evident attempt to keep the plates near the descriptions. The problem, of course, is that, compared with dicotyledonous plants, sedges have a simple morphology. Therefore descriptions are short, and in the case of closely similar species, cannot even be of uniform length. At the end of the book is a four-page glossary, three-and-one-half pages of references, and an index to plant names.

The criticism concerning the waste of space in the drawings which I levelled in an earlier review of the Rushes and Lilies volumes (Canadian Field-Naturalist 87: 82–83, 1973) cannot be equally applied to this volume. Most of the drawings occupy the page although there are a few space-wasters. Some space has been saved by filling in part of the page with text. The drawings of detailed enlargements come out well, but the overall habits and clusters of spikelets are often too dark. This is probably a result of over-shading in the original drawings causing lines to merge with reduction. Because of this darkening, the illustrations do not attain quite the quality of any of the earlier volumes.

Mohlenbrock has made a number of taxonomic decisions which are usually supported by arguments to sustain them and which do not result in any new combinations or descriptions. Some examples are as follows. He adequately disposes of Fernald's division of *Bulbostylis capillaris* into varieties. Again he supports Koyama's contention that *Hemicarpha* should be considered within the generic limits of *Scirpus*, yet he disagrees with his submersion of *Bulbostylis* in *Fimbristylis*, his merging of *Liphocarpa* with *Scirpus*, and his attempt to merge *Eriophorum* with *Scirpus*. I note also that *Scirpus acutus* Muhl., *S. validus* Vahl, and *S. heterochaetus* Chase are regarded as distinct species rather than as variants of the European *S. lacustris* L. as suggested by Koyama.

Undoubtedly the Sedges volume maintains the high standard of the earlier volumes and will certainly provide a valuable tool for the student of sedges in the state of Illinois, in adjacent areas and even further afield because many of the species have broad ranges. May we wish Dr. Mohlenbrock well in his studies on the more difficult group *Carex*, the subject of the second book on Sedges.

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Carex in Saskatchewan

By John H. Hudson. 1977. Bison Publishing House, P.O. 7226, Saskatoon. 193 pp. Paper, $10.00 + .50 handling.

This is a conservative treatment of the genus *Carex*, a notoriously difficult group, in Saskatchewan. The stated purpose is identification. The groups and sections used in the key are those of K. K. Mackenzie (1931–1935) "Cariceae" in *North American Flora* 18: 1–478. The descriptions based on Saskatchewan material of the approximately 100 species are in alphabetical sequence and are for the most part quite extensive. Comparisons are given to related species. Following each description is an informative easily written paragraph or two on habitat, distribution, comments on earlier reports, and treatments of other authors.

Distribution maps are provided for 66 of the more common species. These maps do not, as stated by the author, always depict the true distribution, but rather the distribution of collectors on certain travel routes such as the Hansen Lake road.

Photographs of 40 of the more common species show the habit of these species, but do not show the detail of perigynia often required for the separation of closely related species.

The text is typewritten and is reproduced on only one side of each page, thus making the volume twice as thick as actually necessary. The work is, however, a welcome contribution to a flora of Saskatchewan, which will be most useful to students of that province as well as to those of adjacent prairie provinces.

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The Enterprise Wisconsin, Radiation Forest: Radiological studies

Edited by J. Zavitkovski. 1977. Technical Information Center, Energy Research and Development Administration, U.S. Department of Commerce, Springfield, Virginia 22161. 211 pp., illus. $7.50 U.S.; $15.00 elsewhere.

Radioecological studies in the Enterprise Radiation Forest were initiated in 1968 as a joint effort between the United States Atomic Energy Commission (AEC), Division of Biomedical and Environmental Research, and the United States Department of Agriculture (USDA), Forest Service, North Central Forest Experiment Station, Institute of Forest Genetics in Rhinelander, Wisconsin. Investigators from Michigan Technological University, Michigan State University, and the Savannah River Ecology Laboratory cooperated in some studies.

The radiation project was designed to provide comprehensive information on the effects of ionizing radiation on several typical North American forest ecosystems. The preirradiation studies, 1969–1971, were published in 1974 in a monograph edited by Thomas D. Rudolph entitled, *The Enterprise, Wisconsin, Radiation Forest: Preirradiation Ecological Studies* (USAEC Report TID-26113). These were excellent and were important ecological studies even without irradiation.

Results of the radiation studies are summarized in this new volume. The individual chapters written by the investigators are very well organized and present much new and important information on northern forest ecology. Continuity of most of the investigators is essential in a project of this kind and this was maintained from the preirradiation study through the final report.

Original plans called for five seasonal radiation exposures in various northern forest types and a 5-year chronic exposure of the aspen ecosystem. Unfortunately only one growing-season exposure was actually completed, that of 1972.

Dosimetry of the study site, including horizontal and vertical radiation exposure distribution in the irradiated forest, is presented in the first chapter. Special attention was given to radiation attenuation by tree trunks, other vegetation and topography. Some technical problems with the irradiator may have caused an uneven distribution of radiation in the area during the spring. These problems probably could have been solved had the project continued.

The next two chapters deal with the effects of irradiation on the physical environment in the forest. Changes in light, temperature, relative humidity, and precipitation regimes under radiation-damaged forest canopies are quantified and related to changes in the shrub and herb layers.

Most of the rest of the report emphasizes plant ecology and the effects of gamma irradiation on various plant components of the forest ecosystem, all of which are important contributions to radioecology. Radiosensitivity and effects of radiation on growth of a lichen, *Parmelia sulcata*, are discussed in Chapter 4. Chapters 5 and 7 summarize the effects of radiation on biomass, cover, and composition of the herbaceous vegetation. Chapter 6 quantifies changes caused by irradiation in populations of woody seedlings in the aspen and maple-birch ecotone. Various aspects of the effects of irradiation on production, structure and growth of shrubs and trees are thoroughly presented in Chapters 7 to 11.

Pre- and post-irradiation phenological studies, which have been conducted since 1970, are summarized in Chapters 12 to 15. These present results of phenological studies on 38 species of the herbaceous stratum and periodicity of shoot and radial growth of eight tree species. One of the significant contributions of the Enterprise study is the examination of change through time.

Although mammal sample sizes were very small, possible changes in populations caused by irradiation are described in Chapter 16. Some problems and solutions connected with measurements of radiation exposures of small mammals are presented. Effects of radiation on nesting birds are dealt with in Chapter 17.

Two laboratory studies dealing with radiosensitivity of *Populus tremuloides* seed and gas exchange and chlorophyll content of *P. tremuloides* seedlings grown from irradiated seeds are described in Chapters 18 and 19. Although these studies are interesting, they should perhaps be included in a different report since acute rather than chronic doses of radiation are used.

In the last chapter important findings of the field studies are summarized and the predicted and observed radiation effects on ecosystem components are compared.

Although the termination of the project made the achievement of all original objectives impossible, many findings and some theories reported from previous radioecological studies were confirmed, and some new findings were recorded. Generally this volume is very useful, not only to radiation ecologists, but also to foresters, ecologists, or taxonomists interested in northern forests.

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ENVIRONMENT

Outdoor Recreation in America: Trends, problems, and opportunities

By C. R. Jensen. 1977. 3rd edition. Burgess Publishing Co., Minneapolis, Minnesota. 269 pp., illus. US $12.95.

Issues in Outdoor Recreation

Edited by C. R. Jensen and C. T. Thorstenson. 1977. 2nd edition. Burgess Publishing Co., Minneapolis, Minnesota. 326 pp. US $7.95.

To date there is yet to appear a completely satisfactory book on outdoor recreation and education. Even with the release of these two books, that void still remains to be filled.

Jensen's 3rd edition of *Outdoor Recreation in America: Trends, problems, and opportunities* is so similar to the 2nd edition that the reader is advised to refer to an earlier review (Canadian Field-Naturalist 89(2): 201–202, 1975) for details on this book.

Issues in Outdoor Recreation is a collection of articles and papers from a variety of sources. Although the editors state that "Each one was chosen on its own merits and because of its particular significance," this declaration could be easily challenged.

The papers included in *Issues in Outdoor Recreation* are generally short, 2 to 5 pages in length, and are arranged into 7 chapters. A positive feature of the book is that the majority of the papers selected are relatively recent, having been released within the last 10 years.

The papers appearing in Chapter 1, "The Worth of Outdoor Experiences," do not appear to follow that chapter's theme. The only relevant comment appears in the chapter's introduction: "outdoor recreation is not only a renewing experience but is also serious business both because of its economic impact and its beneficial effect on the physical, cultural, social, and moral well being of the people." The papers of Chapter 1 fail to expand on these concepts, but rather discuss the definitions of leisure, natural resources beauty, and the history of outdoor recreation in America.

The papers of Chapter 2 more closely adhere to the chapter's theme, "Social and Economic Influences." Shaw's paper, "Today's unsolved problems — tomorrow's crises," clearly identifies the four major problems facing today's resource managers: water supply, waste management, management of space, and management's function in a modern society.

Stewart Udall's address at Utah State University while he was Secretary of the Interior, clearly outlines the conflict between social and economic influences "the true worth of a nation — its inner greatness — lies in the quality of its life rather than in its economic indices, or the quality of goods it provides for its citizens."

"Resources, Diminishing Supply, Escalating Demand" is the title of Chapter 3. This chapter includes papers on bikeway planning, state parks, winter recreation, camping facilities, trails, and wilderness. Several of the papers might better have been assigned to Chapter 6 which deals with planning.

"The Economics of Outdoor Recreation" are dealt with in Chapter 4. The obvious omission within this chapter is the lack of information about consumptive forms of recreation such as hunting and fishing.

"Preserving the Recreation Environment," Chapter 5, includes papers on environmental ethics, waste management, noise pollution, water pollution, and law and order in parks. Ditton's paper "Wreckreation in our national parks" points out the major paradox of outdoor recreation. "It may be difficult to consider recreation as a pollutant, because we have been saying all along that recreation is the first to suffer from water pollution and other environmental degradations."

The papers of Chapter 6 consider planning and management. Bury, in his paper "Recreation carrying capacity — hypothesis or reality?" points out the problem of equally weighing biological, sociological, cultural, and physical constraints. This chapter is rather weak considering the amount of literature devoted to this topic.

"Education: Needs and Responsibilities," Chapter 7, is the final collection of papers in the text. Without public education, the future of outdoor recreation is in doubt. "The need for educating people to use outdoor recreation areas has increased with the ever-expanding population and the diminishing open space available for recreation pursuit."

Issues in Outdoor Recreation is not a noteworthy text. Educators instructing in outdoor recreation planning might consider this text useful as a supplement to their course.

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Fundy Tidal Power and the Environment

Edited by G. R. Daborn. Proceedings of a workshop on the environmental implications of Fundy tidal power held at Wolfville, Nova Scotia, November 4–5, 1976. Acadia Institute Publication Number 28, Wolfville. v + 303 pp., illus. Paper $10 prepaid; $11.50 charged.

It was in the early 1940s that Canada first looked seriously at the feasibility of generating electrical energy from Fundy tides. The basic concepts for exploiting tidal energy (upward-acting lunar gravity) are quite different from the engineering designs utilized in harnessing river hydro power (downward-acting terrestrial gravitation). Technologies at that time were inadequate for the Fundy development, and no innovative approaches were forthcoming during the next two decades.

By 1966 it was concluded that tidal power development was technically, but not economically, feasible. In that year the Government of Canada and the provinces of New Brunswick and Nova Scotia jointly initiated a study of the feasibility of large-scale power development in the Bay of Fundy.

In 1972 the same three governments established the Bay of Fundy Tidal Power Review Board. Fossil and nuclear fuel costs had risen sharply and tidal power development began to look more attractive economically: " . . . the longer term advantages of sources of energy that are renewable . . . cannot be denied." Consequently in November 1976, the Acadia University Institute hosted a multidisciplinary workshop on the environmental implications of tidal power development in Fundy. This book is the proceedings of that workshop.

The book is divided into four parts, each part containing a number of related papers presented at the workshop. A brief review of each section is in order.

Part I. Engineering Design and Initial Environmental Implications

The six papers in this section discuss engineering design, construction, and operating concepts, and provide a preliminary look at socioeconomic and environmental considerations. The basic scheme entails the creation of a basin or basins by construction of a dam across a tidal inlet to capture a particular state of the tide. Energy would be produced by releasing water through the hydraulic turbines in the dam. Power generation would occur in 4- to 6-hour surges.

The sheer magnitude of the project clearly suggests that there would be some effect on the environment. Preliminary observations of these effects are discussed using a nine-component interaction matrix. (There will be more specific comment on this in Part II.) Preliminary socioeconomic analysis suggests that because of its uniqueness the development may have distinctly different social and economic results.

Part II. Physiography and Environmental Characteristics of the Bay of Fundy — Gulf of Maine System

The largest section of the book contains 10 papers describing the physical and biological character of the bay.

There are structural and geophysical anomalies known for the region. These geologic and tectonic data suggest that careful study and analysis should precede any interference with the natural regime. But, as a paper in a later section pointed out, the worse that can happen here is that an inevitable earthquake will occur sooner than expected.

In one of the papers dealing with the biological resource it was stated that conventional fishing will no longer be possible in areas behind the tidal barriers. This paper describes the major fisheries in the bay and states that 3700 fishermen land $17 million worth of fish within the Bay of Fundy.

Fundy avifauna is well documented. Shorebirds will clearly be affected since Maritime estuaries are major staging areas for migrating shorebirds. Upper Bay of Fundy is a critical feeding stopover and one of the most important areas for birds in eastern North America.

Part III. Interrelationships of Environmental and Engineering Parameters

The four papers in this section discuss the possible effects of the development on physical oceanography, on sediment transport, on the possibility of earthquakes, and on land-based near-shore resources. Data of this type can best be presented in other than narrative form. Fifty-six of the 85 pages in this section are devoted to numerical models, graphs, figures, maps, and tables.

Part IV. Prospectus: Reports from Discussion Groups

In this section eight "rapporteurs" summarize the discussion generated in four separate discussion groups: Physical Oceanography, Geology, Chemistry, and Biology. In addition to providing a summary, the "rapporteurs" also examined research priorities.

This is an important book for the scientist and the engineer, and for the public. Twenty-six specific questions were examined during the workshop. Papers by government personnel, university scientists, and consultants provide a comprehensive (albeit preliminary) look at the environmental implications of Fundy tidal power. The editor is to be complimented for a number of reasons, not the least

of which are the small number of errata in a book produced so quickly, and that he permitted some updating of manuscripts while the book was in the early stages of organization and printing.

Clearly there will be some negative effects if development proceeds. For example, a biological scientist would be aware that the intertidal zone in the bay is an extremely extensive ecosystem because of the unusually large tidal range. There would be significant impacts to the benthic community and to shorebird numbers. Engineers would relate to predictions of change in the tide regime and to siltation rates. Socioeconomists would know that engineering projects, even large ones, have run into serious opposition because planners underestimated the real or perceived impact on society.

In his closing remarks, Dr. A. E. Collin, workshop chairman, emphasized that the task is not to embark on a program to understand the working of the Bay of Fundy. Rather, it is to move "toward the best and most effective environmental understanding of the implications" of the development. He further stated that "we have no model of how to proceed in the evolution of decisions that are necessary with regard to the Bay of Fundy." This workshop which exposed scientists of all disciplines to one another's techniques, results, and problems must be considered a significant event in the game plan.

Can Fundy tides be developed without disastrous environmental consequences? It is a concensus from these papers that the existing data base is inadequate for predicting possible impacts.

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OTHER

My Life among the Eskimos: the Baffinland Journals of Bernhard Adolph Hantzsch — 1909–11

Translated and Edited by L. H. Neatby. Foreword by G. W. Rowley. 1977. Mawdsley Memoir 3. University of Saskatchewan, Saskatoon. 395 pp., illus. $20.

Hopefully now, Bernhard Hantzsch, sixty-six years after his death near the river that bears his name in west Baffin Island, has been assured of his place in the annals of polar exploration. Recognized too should be his loyal companions on his epic and tragic journey, John (Jimmy) Aggakdjuak, his brother Ittusakdjuak and the latter's wife Sirkinirk, more especially. The assurance for their belated recognition properly should derive from the translation and skilful editing of Hantzsch's Baffin Island journal, the handwritten original of which appears to have been lost. Fortunately, however, a photocopy of an early German typescript of the diary providentially survived in the Public Archives in Ottawa. All credit goes to L. H. Neatby, the distinguished Canadian arctic historian, for undertaking the task of translation and editing this record, and for enlisting the aid of several other arctic specialists to provide additional commentary that materially enhances its value to the concerned or casual reader.

Much could be written about the likely interest that Hantzsch's record would have for a variety of audiences, wider certainly than the area specialists, biologists, ethnologists, and geographers who had backed the German schoolteacher's ambitious plans for comprehensive exploration of unknown arctic lands. He was certainly something of the Renaissance man, the cultured man of faith, letters (a poet in fact), and natural philosophy, in this instance writing his testament and fulfilling his purpose under the most arduous conditions, yet rarely allowing his sensitivity to the awesome power and beauty of nature to be diminished by the often extreme circumstances under which he toiled. It was as a naturalist, primarily, that he journeyed to the Arctic, and therefore it is most appropriate for the present review that comment be restricted to those biological topics on which he wrote.

At the time of his Baffin Island sojourn, Hantzsch had already contributed to knowledge of the boreal zone avifauna, with authoritative monographs published on the birds of Iceland and northern Labrador. Thus despite the loss of his collecting equipment in a Cumberland Sound shipwreck (that contributed to the eventual tragic outcome of his valiant expedition), his sight records need not be seriously questioned and with the possible exception of an alleged sighting of an Ivory Gull, Hantzsch recorded 38 bird species, collecting the eggs, skins, and feet of many of these. Several of his sightings were new for Baffin Island: American Golden Plover, Black-bellied Plover, Baird's Sandpiper, Semipalmated Sandpiper, and Horned Lark. His diary

provides observations on the phenology of the region: the order of reappearance of spring migrants in 1910—Snow Buntings, eiders, gulls, King Eiders, Snow Geese and Peregrine Falcon, etc.; the first bunting's song (May 24); the first mass attack of body lice (May 25); the stirring of flies, caterpillars, and spiders (May 28); *Saxifraga oppositifolia* in flower (June 17), and so on. Interestingly one reads that the following spring, the first returning migrant encountered on the west coast of Baffin Island was the redpoll (on April 18, 1911), not the Snow Bunting.

Hantzsch recognized the enormous store of zoological knowledge possessed by his Inuit companions, and strove to learn the language and question them on matters of biological interest. He realized that information relating to actual dates could not be elicited from his informants, so with the humility of the true scientists he observed "so in this matter the research scientist has no choice but to contend himself with what he can himself observe and on this he can generalize only with caution." Thus he is careful to note, when commenting on the Ringed Seal living in the fresh water of Nettilling Lake (a form at that time unknown to science), that his observations derive from the accumulated knowledge of his Inuit companions who were quite familiar with the animal. He provides interesting contrasts between the freshwater stock and that from the Cumberland Sound marine environment: the lake seals are said to have a smaller outer eye opening and larger inner eye opening, shorter forehead, lighter pelage, less spotted belly, tougher skin, and flesh more tender and with less odor. He surmises, on the basis of the worn dentition and hence the older age of the lake seals, that they live their lives entirely in the lake. The alternative explanation, however, that the lake population freely communicated with the unexploited (and hence older) marine Ringed Seal populations of eastern Foxe Basin did not, at that point of Hantzsch's writing, appear to have been considered.

Elsewhere too, there occur occasional diary entries that likely would have been amended in the careful post-expedition writing-up that tragedy forestalled. For example, the finding of a whalebone and walrus jaw bone near the southern shore of Nettilling Lake prompts the conclusion that those animals formerly lived at that locality; however, such chance finds hardly constitute acceptable evidence of marine transgression when in the immediate vicinity were tent rings and seal bones of the Taliopingmiut inhabitants of earlier times. In fairness to his considerable scientific and inferential abilities, however, one must bear in mind the context in which new discoveries were being noted in his daily journal and the elation, if not exuberance, of the explorer treading ground never before reached by a European man of science.

Though we can regret the preliminary and thereby partial, nature of the scientific record that survives, there can be no doubt that had the venture succeeded anywhere near as fully as planned, the outcome would have ranked Hantzsch near the very top of scientist-explorers, for here was another Franz Boas the scientist, coupled with the zeal and ambition of Stefansson and Hall the adventurers. This book provides ample evidence of the enormous potential and actual achievements of this man.

Book production is mostly excellent, with thoughtful provision of a comprehensive index and separate map providing ready access to all places and campsites referred to in the accompanying text. The few minor errors that appear in the book are inevitable for a work of this scope and size, and for the most part are unlikely to worry either the informed reader or the non-specialist. Errors are often due to nomenclature changes occurring over time or shifts from European to American usage (e.g., loons/divers, linnets/redpolls, *Tripholium/Eriophorum*) or derive from errors in the initial retyping from the handwritten original (where 'u' becomes transposed to 'n' (as in Nandlak/Naudlak, Taliopingmint/Taliopingmiut, etc.) or where 'o' becomes 'a' (as in *Gasterasteus/Gasterosteus*)). Incidently this last represents a significant error, as the record of *G. aculeatus* (written as *Gasterasteus - Art*) constitutes, to this day, the most northerly record of this fish over its discontinuous Nearctic range. Altogether though, this book is a stirring account of an honorable undertaking and is highly recommended reading.

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*Assigned for review
†Available for review

Notice of The Ottawa Field-Naturalists' Club Annual Business Meeting

The 100th Annual Business Meeting of The Ottawa Field-Naturalists' Club will be held in the auditorium of the National Museum of Natural Sciences, Metcalfe and MacLeod, Ottawa, Ontario on Tuesday 9 January 1979 at 8:00 p.m.

Diana R. Laubitz,
Recording Secretary

Correction to page 262 (July-September issue)

The complete photograph of Figure 1 was not printed. It is reproduced below as it should have appeared in the article.

Asexual Reproduction, Diet, and Anomalies of the Anemone *Nematostella vectensis* in Nova Scotia

Peter G. Frank and J. Sherman Bleakney

1978. Canadian Field-Naturalist 92(3): 259–263.

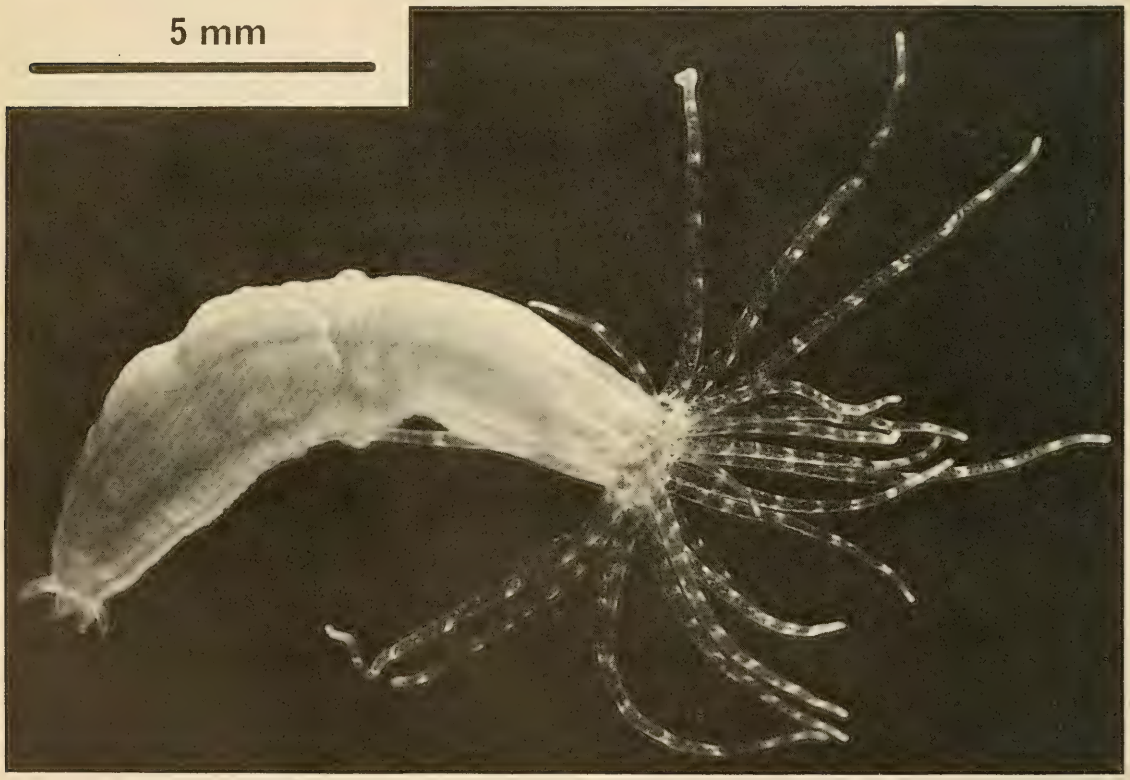

Figure 1. *Nematostella vectensis* from Minas Basin, Nova Scotia. Note the tentacle buds in addition to the 20 full-sized tentacles.

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Erratum

Canadian Field-Naturalist 92(1): 61–66. 1978

Recoveries of Saskatchewan-banded Great Horned Owls by C. Stuart Houston

The total number of Great Horned Owls banded was 2329. Therefore, the number 2229 in paragraph two of the Results and Discussion on page 61 and in Table 2 on page 62 is in error; it should be 2329.

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